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To Build with Light:
An Exploration Into the Relationship Between Light, Space, and Built Form

by Michael Thomas Heffron

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1986

Submitted to the Department of Architecture in partial fulfillment of the requirements of the degree of Master of Architecture at the Massechusetts Institute of Technology

June 1989

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May 12, 1989

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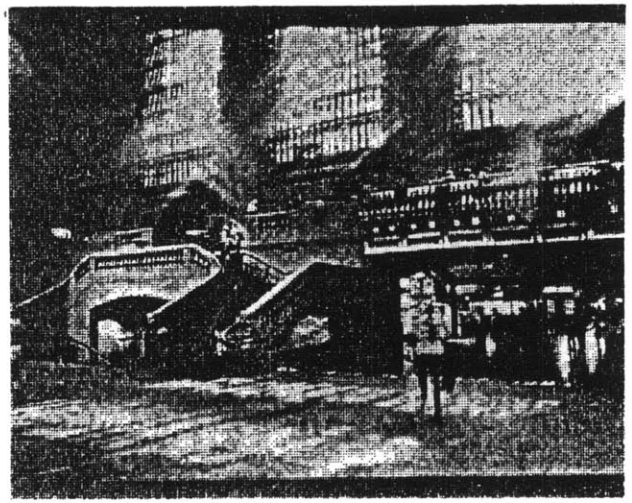

To Build with Light:
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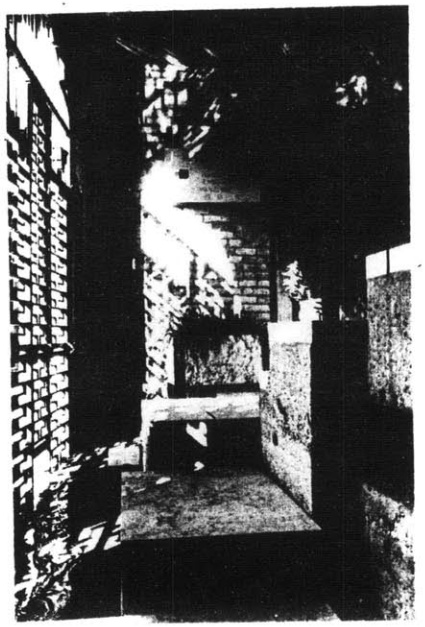
ABSTRACT

The purpose of this thesis is to look at how light works with form to generate space. The thesis attempts to deal with the physical reality that light, space and form exist in a symbiotic relationship. The thesis deals with this relationship by exploring the architectural phenomenon that are generated from this relationship. It therefore does not try to deal with light in a technical manner, nor does it attempt to delve into the metaphysical and emotive qualities that can be attributed to light.

The thesis uses a cyclical process of observation, analysis and testing. A wide range of references are presented both in the form of images and actual built lighting models. These are organized into five categories of light phenomenon and analyzed for underlying principles of the light form relationship. The principles abstracted from this research are then tested in a design.

Thesis Advisor: Thomas R. Chastain
Title: Lecturer



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ill.3

Acknowledgements

First, I'd like to thank Tom Chastain for his guidance, for pushing me, and for making it clear.

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Many thanks to my fellow students, Fibs, Wolfy, et al for sharing with me your great wealth of experiences and viewpoints.

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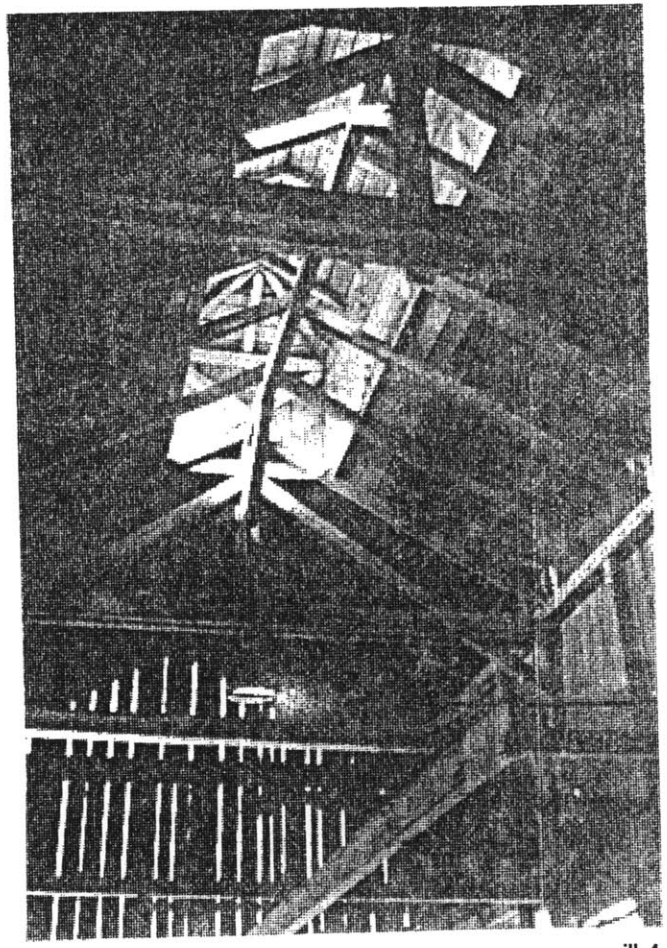
Thanks to the Heffrons and the Cottinghams for the constant support.

And most importantly to Marni for everything. This thesis is dedicated to her.

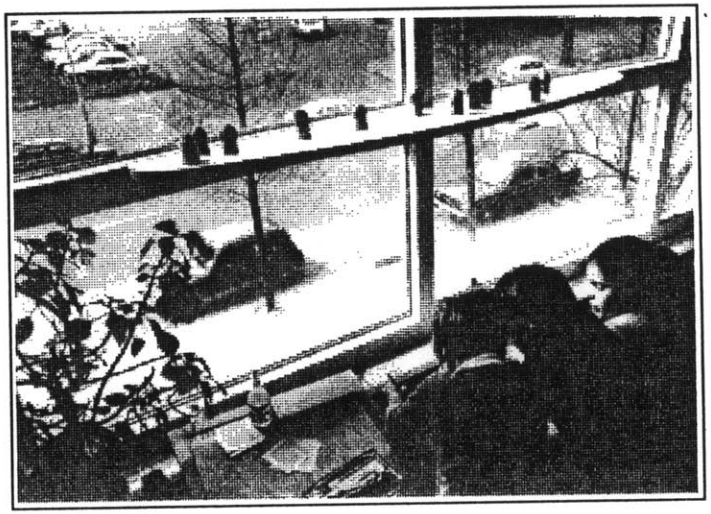
Table of Contents



ill.4

" We put thirty spokes together and call it a wheel;
But it is on the space where there is nothing that the
utility of the wheel depends.
We turn clay to make a vessel;
But it is on the space where there is nothing
that the utilitiy of the vessel depends.
We pierce doors and windows to make a house;
and it is on these spaces where there is nothing that
the utility of the house depends.
Therefore, just as we take advantage of what is,
we should recognize the utility of what is not."

- Lao Tse



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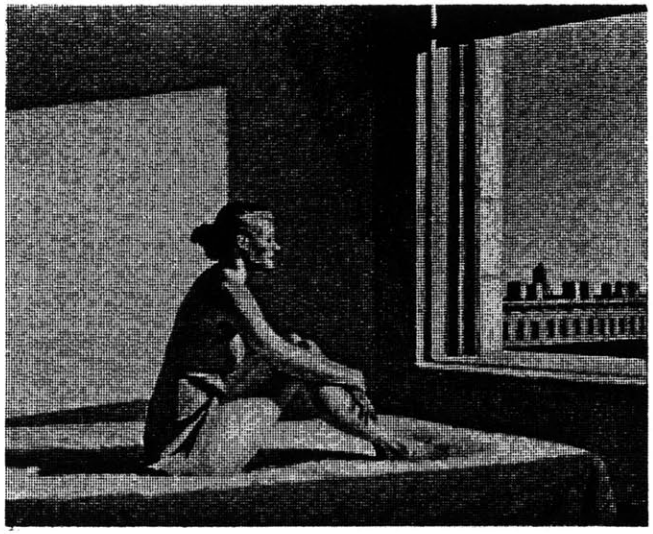

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"...As far as we can discern, the sole purpose of human existence is to kindle a light in the darkness of mere being..."

- C. G. Jung,
Memories, Dreams, Reflections

"The study of light... is something more than a mere investigation of illumination. Light and things belong together, and every place has its light. Light, things and places can only be understood in their mutual relationship. The phenomenology of things and places is also the phenomenology of light. In general, they belong to the phenomenology of earth and sky. The sky is the origin of light, and the earth its manifestation. Therefore light is the unifying ground of the world.
Always the same and always different, light reveals what is."[1]

- Christian Norberg-Schultz

Light is crucial to our existence. Besides the physiological benefits, there are a number of psychological and emotional benefits that are directly linked to exposure to natural light. *The* constantly changing nature of daylight automatically and naturally accommodates the mind's need for a change of stimuli. *The* movement of the sun through the daily cycle is a natural reference to both time and north-south orientation. *Natural light* produces a gradation of light on surfaces and objects that appears "natural" to humans because the color and intensity of natural light is constantly changing -- without these changes in stimuli, spaces and materials lit only by artificial sources can feel "unnatural". *Finally,* we obtain most information about our environment through our eyes, and light makes this possible. This is the most of the important aspect of light because it enables us to orient ourselves relative to spaces and forms -- the two components that make up any habitable built environment.

"Vision is primarily a device of orientation; a means to measure and organize spatial events. The mastery of nature is intimately connected with the mastery of space; this is visual orientation."

"Vision is not only orientation in physical spheres but also orientation in human spheres."[2]

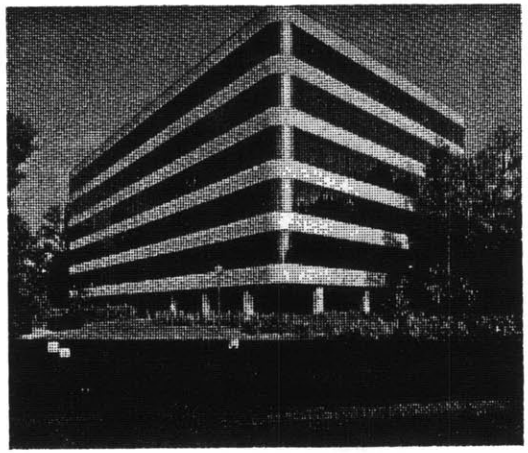
- Gyorgy Kepes

Why, given the importance of light, is its relationship to space and form often ignored in the design of architecture?

A basic assumption of this thesis is that Architecture the manipulation of forms, spaces, and the symbiotic relationship that exists between the two, not style or technique. In his book The Architecture of Humanism, Geoffrey Scott writes,

"The function of the arts, at many points, overlap; architecture has much that it holds in common with sculpture, and more that it shares with music. But it has also its peculiar province and a pleasure which is typically its own. It has the monopoly of space. Architecture alone of the Arts can give space its full value. It can surround us with a void of three dimensions; and whatever delight may be derived from that is the gift of architecture alone."[3]

Others have also discussed the importance of space in Architecture. Bruno Zevi's book Architecture of Space is dedicated to recording the history of



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"Architecture will be brought to its fullest realisation only
10 when the deepest knowledge of human life as a total phenomenon in the biological whole is available. One of its most important components is the ordering of man in space, making space comprehensible, and taking architecture as arrangement of universal space.
The root of architecture lies in the mastery of the problem of space, the practical development lies in the problem of construction."

- Lazlo Moholy-Nagy

"The architect has finally discovered the medium of his art: S P A C E."

- R.M.Schindler
Modern Architecture: A Program

ill.8

Architectural space through the various ages from ancient times to the present . He writes,

"That space should be the protagonist of architecture is after all natural. Architecture is not art alone, it is not merely a reflection of conceptions of life of a portrait of systems of living. Architecture is environment; the stage on which our lives unfold."[4] And, *"...it is in space that life and culture, spiritual interest and social responsibility meet. For space is not merely a cavity, or void, or 'negation of solidity'; it is alive and positive. It is not merely a visual fact; it is in every sense, and especially in a human and integrated sense, a reality in which we live."*[5]

What sets Architecture apart from the other Arts is that Architecture is a three-dimensional experience -- we can inhabit it.

Standard Approaches to Understanding Light

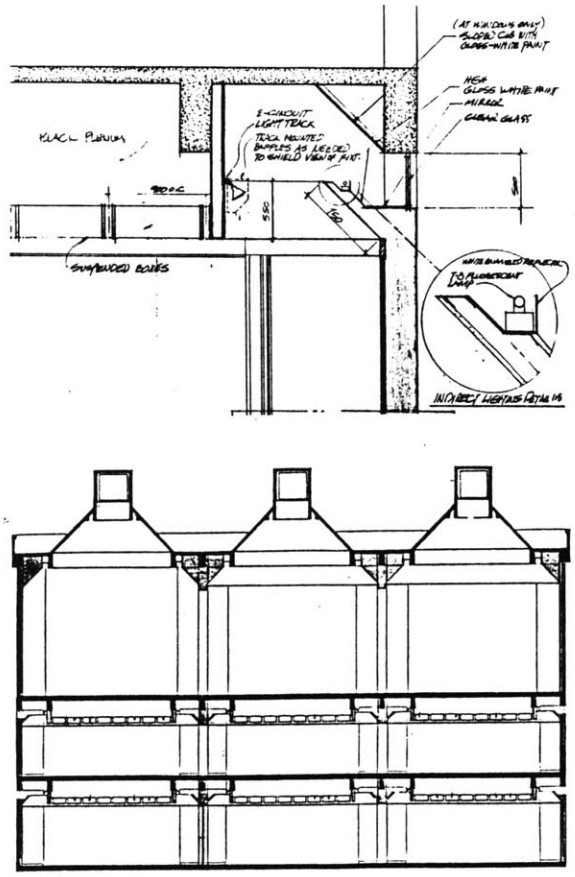
How can light be used to strengthen this spatial experience? There are two standard approaches to studying the behavior of light in the built environment; the technical approach and the literary approach. The first approach does not address the light-form relationship because it tends to treat light as a material that can be manipulated to solve problems of technical performance. The literary approach is reactionary. It records personal experiences of space and light. Neither approach explores the underlying relationship between light, space and form.

The Technical Approach

There exists a large body of information on the use of natural light to augment the need for artificial lighting in buildings. Most of the information is in the form of manuals that focus on the technical issues of lighting a building: the physics of light, their reflectivity quotients of various materials, how to deal with glare problems and achieve "proper" illumination levels, etc. The goal of these manuals is to encourage the use of daylight instead of artificial light to meet various lighting needs, and to save energy. The lighting needs of a building are often dictated by codes. These codes set standards for light levels based on predicted activities that will occur in various building spaces (for example, 10 foot candles for a hallway or 40 to 50 footcandles for office space).

But because of the natural adaptability of the eye our perception of light quantity is relative, and therefore precise measurable levels of illumination are somewhat suspect as to how well they correspond to the way we associate with light. As S.E. Rasmussen points out,

"... variations in the quantity of light can be ignored, for though they can be measured with the help of instruments, we ourselves are hardly aware of them. Bright sunlight may be 250,000 times more intense than moonlight and yet we can see the same forms in the light of the moon as we can in broad daylight."[6]



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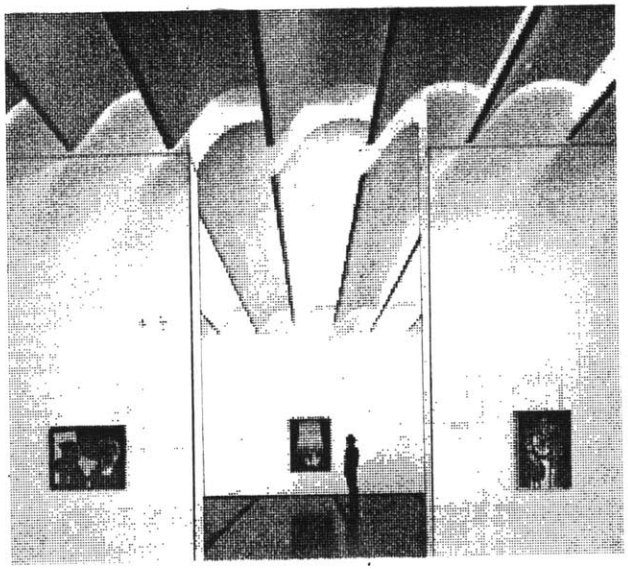
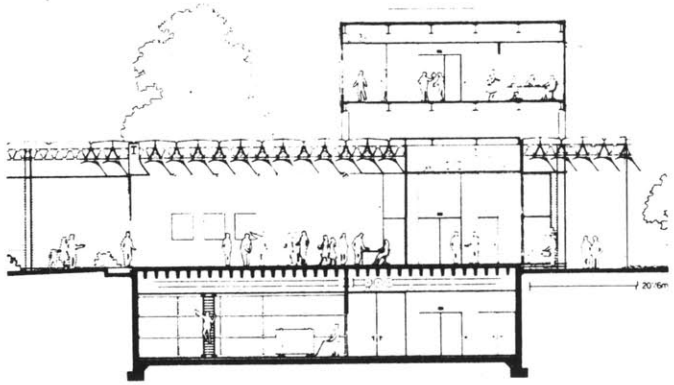
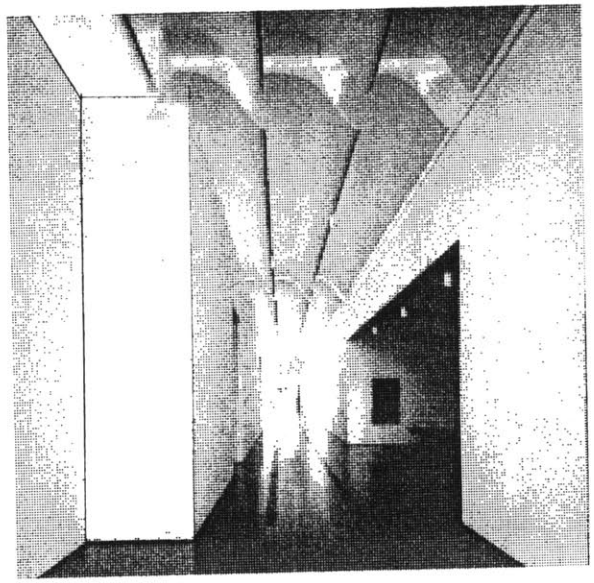
The above illustration is a detail for a museum lighting situation. Although this may solve the problem of bringing in daylight without the dangers of direct sun exposure, it is an idiosyncratic solution to getting some indirect light into an interior space. And because the same section is used at the interior walls as an elaborate cove light with an artificial source there is no formal gesture to acknowledge the difference in the two types of light.

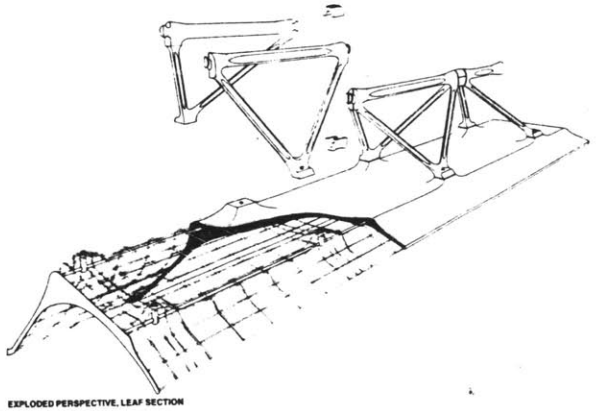
What typically happens in the technical approach to working with light is that a lighting need is recognized based on a programmatic requirement. For example, a gallery space needs to be free of direct sunlight to protect paintings from ultra violet radiation. The lighting needs are then met with a technically appropriate form for all exterior openings so that only indirect "daylight" is allowed into the space. Often, the forms of these lighting devices have little to do with generating any kind of associations with the natural light coming from outside, and will often function as a type of installed or applied light fixture rather than a part of the larger building form.

An example of this type of lighting approach can be seen in the recent design for an art museum in Houston, Texas by Renzo Piano. In an article featuring this building, appropriately titled "The Responsive Box", CAD images and functional diagrams of the special precast concrete "fin" are shown. The fin was designed specifically for this project to achieve uniform light throughout the building's exhibition spaces. The article also contains photos of various locations within and around the building where the use of these concrete fins becomes apparent. The fin element is simply repeated ad infinitum across the ceiling of the building much like the use of the neutral column grid in many speculative office buildings. These fins cover both exhibit spaces and circulation spaces as well as exterior porches at the front and sides of the building, always in the same form and size. This is similar to the luminous ceiling idea of the early 1970's where the entire hung ceiling of an open office space was filled with artificial light fixtures with the goal of giving even light levels to the entire space.









EXPLODED PERSPECTIVE, LEAF SECTION

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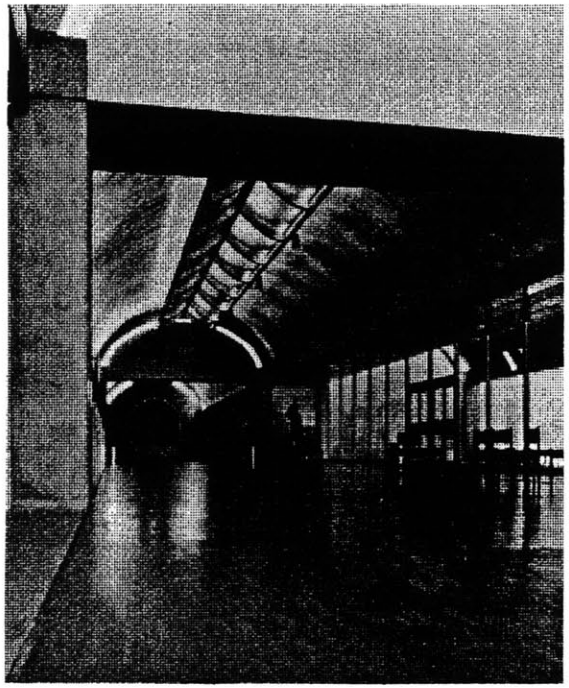
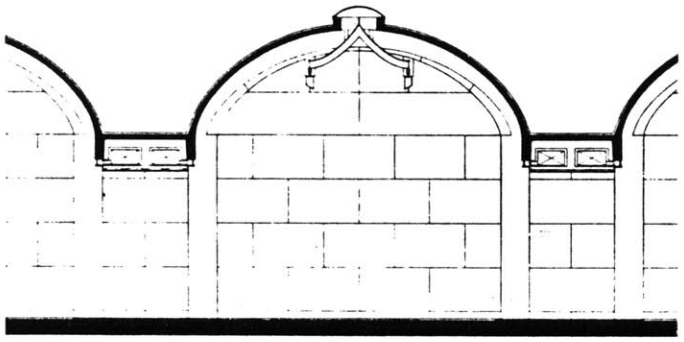




Section showing one of the cycloids

ill.11

Compare this approach to daylighting a museum with the approach used in Kimbell Art Museum in Fort Worth, Texas by Louis Kahn. Kahn faced a similar problem of bringing indirect light to a gallery space. Kahn also developed and used a technically appropriate device, but he utilized the form of the gallery ceiling as a crucial part of the lighting solution. The light comes through the skylights in the center of the vaults and is reflected into the curve of the vaults. This diffuses the light and spreads it around the vault, filling the space with light. Hence, the light is integrated directly with the form and generates the gallery space.

In an article about using technical means to solve Architectural "problems" Alvar Aalto wrote,

"To make architecture more human means better architecture, and it means a functionalism much larger than the technical one. This goal can only be accomplished by architectural methods -- by the creation and combination of different technical things in such a way that they will provide for the human being the most harmonious life." [7]

Using natural light in buildings to satisfy certain performance requirements is important both from an ecological as well as an economical standpoint. But the need to control natural light through technical means should never hinder the opportunity for working with light to generate spaces that enhance the associative qualities of a building.

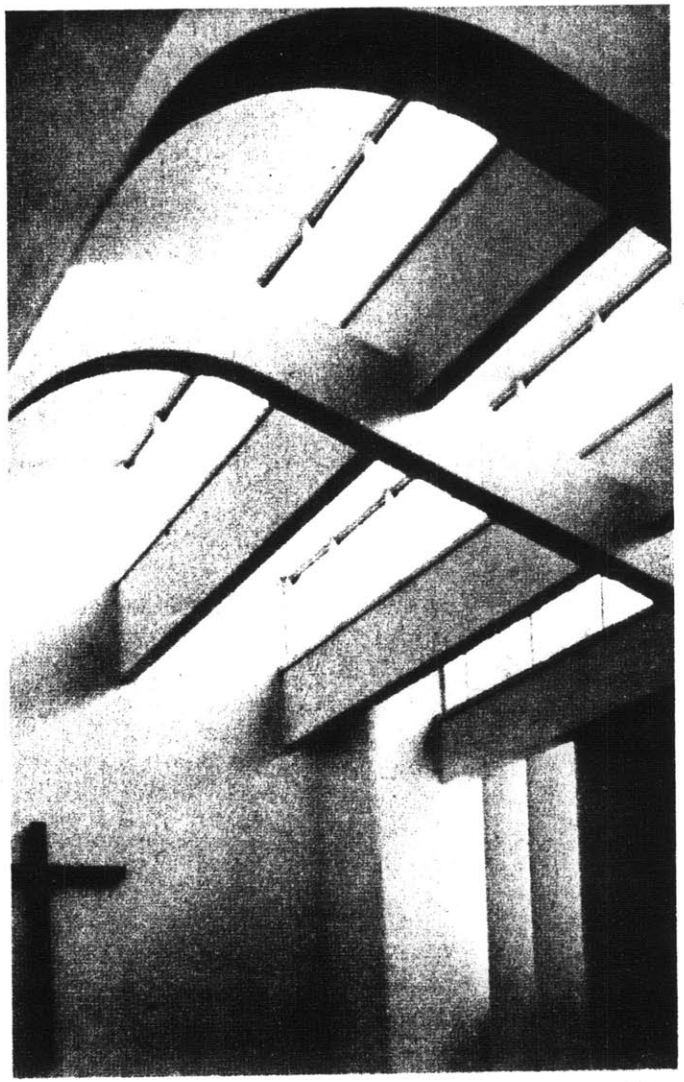
Literary Approach

There has also been much prose dedicated to describing the quality of light in the environment. This is an impressionistic approach to light that reacts to the space as it is experienced and attaches emotive or metaphysical qualities to those experiences rather than analyzing the places' physical properties for what might have elicited these experiences. Henry Plummer's recent book The Poetics of Light is an exploration of this type. In the opening chapter he writes.

"...light is not merely an agent of clarity, serving to illuminate shapes and convey data. There are occasions when a swelling light actually penetrates into the very structure of things, brightening them so from within that they seem to shine translucently. We sense at these times a profound change in the state of matter, and in the relations between light and form, for instead of the material and immaterial opposing each other, or one dominating the other, the two partners enter into a mutually enlivening exchange."[8]

He then proceeds to describe the light qualities of various noteworthy building and places through narratives and photos. The following is a passage describing the light in the church Santa Maria Di Assunta in Riola, Italy by Alvar Aalto.

"A stream of gentle north light enters from above through enormous scalloped monitors, which is then further decolorized and muffled by



ill.12

reflections inside the rooftop chambers, and eventually released as a serene white mist into every hollow of the church. Secluded recesses that might otherwise be left dark are somewhat penetrated by this airlike glow, so that the whole vessel is a cloud of whiteness. Cast shadows lose all their articulation and body, becoming rarefied into thin sprays and painted imperceptibly into a drawn our sfumato. Balmy imprints of light spread into ghostly and dematerialized veils, seeming to interpenetrate and slide through each other."[9]

This is a description of the metaphysical qualities of the space, and Mr. Plummer has chosen not to include plans, sections or any other drawings as part of his descriptions; hence heightening the mystification of the building. There is no opportunity to try and understand how the physical form of the building is working with light to elicit such qualities.

The literary approach presents two problems to the designer. One is that it gives little objective or principle information about the space that could then be used in the making of other spaces where a similar light condition might be desirable. Paul Klee understood this deficiency when he wrote of his own frustrations in trying to convey notions of space in writing.

"For in language there is no way of seeing many dimensions at once... Unfortunately, what the so-called spatial arts have long succeeded in accomplishing... this simultaneous view of many dimensions which is the foundation of the great climaxes of drama, is unknown in the realm of verbal explanation."[10]

The other problem is that these observations are quite subjective because they are so intensely personal, and although some images might be shared, each person will have a different interpretation of the same space. Different interpretations are desirable, and I believe that the richness of a place is the ability of that space to elicit a multiplicity of experiences. But, it is difficult to abstract more general principles from such subjective observations. Therefore, it is the direct sensory experience and perceptions of the underlying form that are most useful to observe.

These are two perspectives in which light is discussed relative to its relationship with architecture -- the technical approach and the literary approach. The performance approach brings the designer valuable information on the physical behavior of light in regards to materials and forms. But this approach is limited by performance guidelines and is still largely based on quantities of illumination for specific uses, and often results in light "fixtures" rather than associative building forms. The technical approach does not address the fact that there can exist spaces having identical light levels that also have completely different forms and hence drastically different light qualities. The "literary" approach to understanding light in the environment can offer strong emotive images of a space as it is experienced. What these descriptive studies of light seldom explore is how these experiences are triggered by the physical form. Therefore, the descriptions do not contribute information on how these experiences are really tied to and generated from the physical interaction between light and form.

" If whatever a painting is could be described with words... there wouldn't be a painting, or a need for painting."

- Susanne Langer
Feeling and Form

" As one leaf/system finds itself next to another... they 'build' the space in between; hence, built fern/form. If there was no space/no light between...the leaf would die. What about buildings?"

The New Method

"Our human nature is profoundly phototropic. Men obey their deepest instincts when they hold fact to light in comprehensive acts of perception and understanding through which they learn about the world, orient themselves within it, experience joy in living, and achieve a metaphoric, symbiotic grasp of life."[11]

Light is continuous -- we are always associating with light, but because light itself is immaterial, we only perceive it when it is transformed by physical form. Therefore light "moves" through space and when it is stopped by physical form, the perception of space is generated. Can these forms be structured so that they build associations with light that help us to experience space and orient ourselves in the environment? I believe that not only can these opportunities for association with light be generated, but that anytime form is manipulated these associations are inevitable.

"Every Architectural form, every building or group of buildings, regardless of the practical purpose or the expressive need that formed it... is a visible form built from differences of light qualities,...Without our perception of these patterns of light, our distance sense, our appreciation of the qualities of our wider space, would completely disappear."[12]

"For light possesses tremendous psychological power since it is so deeply immersed in the furthermost recesses of our unconsciousness and is so

intimately fused with our space experience as to be almost identical with it. For visible space is lighted space, and with light therefore, we can evoke space experience.. For light is one element; material object another, and the relationship of one to another makes up our visual world."[13]

- Nathan Lerner

Light, through its relative brightness and color, its relation to the different hues, textures, opacities and transparencies of materials and their dimensional distribution, is directly linked to our understanding of physical form and its spatial component, territory. To make our environment more habitable through the generation of form that works with light it is necessary to understand more clearly the intricacies of the relationship between light, space and form. Therefore this exploration is an attempt to find an alternative approach to studying and describing the role light plays in generating this relationship.

"*...even a space intended to be dark should have just enough light from some mysterious opening to tell us how dark it really is..."*[14]

- Louis I. Kahn

Method of Exploration

The study of light in Architecture has two dilemmas. First, light is by nature dichotomous, we can experience light coming from a source such as a windows, skylights, screens, diffusers, wall textures or the sun. But we can also experience light as a volume that surrounds us where light begins to have a phenomenological qualities. This dichotomous dilemma has also been recognized in physics.

"For physicists, too, the actual nature of light is difficult to describe and measure. They can choose to describe it as a particle or as a wave, but not both at the same time. In other words, how we perceive the world is largely determined by how we choose to approach it."[15]

I have chosen five ways of looking at light, or rather five light phenomenon:

- light as a continuity
- light as structure
- light as a connection
- relation of light and screens
- light as a containment

These categories were decided upon after looking at a wide range of references in photos and drawings. They certainly are not the only categories that could have been derived from the initial references, but they were ones that developed as the references started to become organized.

They will be presented in five sections corresponding to the five light phenomenon I chose to study.

The second dilemma in studying light, which has already been implied, is that light, like space, is a three-dimensional phenomenon. The use of only two-dimensional images would not allow a complete understanding of the spatial qualities of the five light phenomena mentioned above. Therefore five references were physically modelled at a large scale to allow qualitative observations and analysis to be made of light acting temporally and in three-dimensions. The selection of references to be modelled was based on their exhibiting all or some of the light phenomena being studied, and due to time constraints, on availability of documentation and ease of construction. One model reference is presented at the beginning of each section.

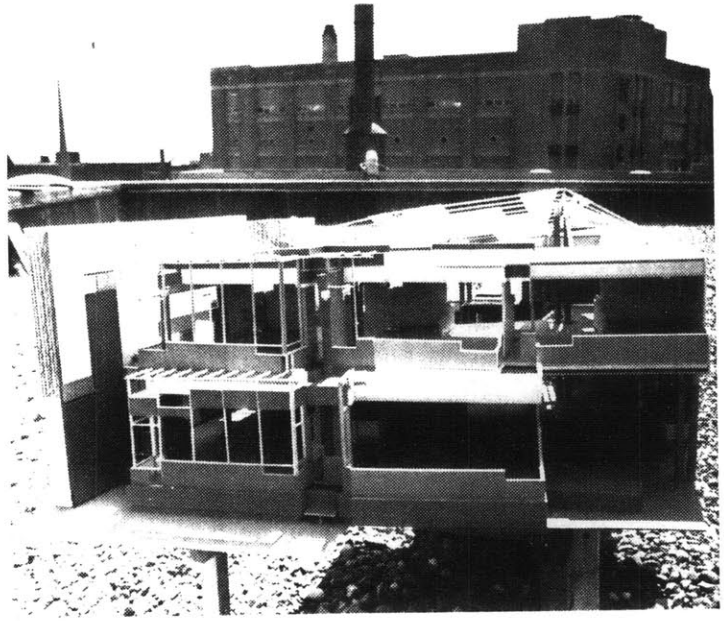
The design of a primary school became a vehicle for testing the principles that were observed and abstracted from the references. The design was developed through models as well as drawings to allow for three-dimensional spatial qualities to become more readily apparent. The design progressed in parallel with the reference research thus completing a cyclical process of observation, analysis, and testing.

"If Childhood is a jouney let us see to it... that the child does not travel by night."

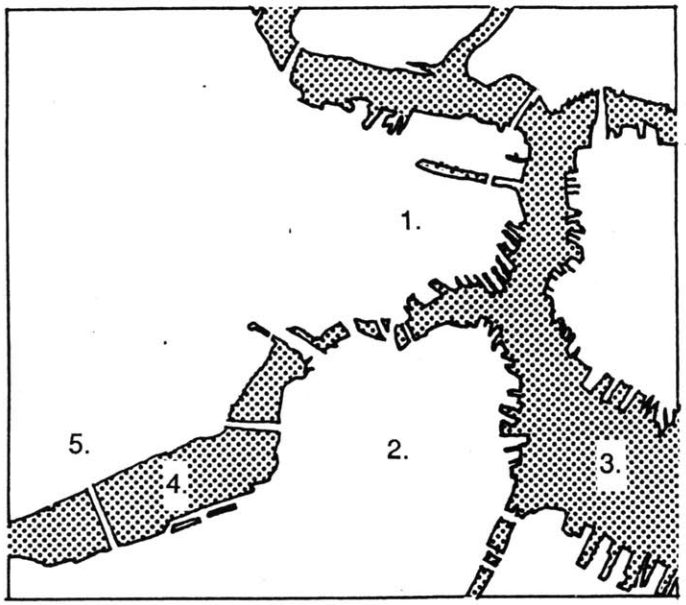
- Aldo van Eyck

The Bunker Hill Primary School

This chapter presents the design section of this thesis. The program for the design is a primary school containing four classrooms, kindergarten through the third grade, and a daycare/preschool. It includes some administrative offices, a library, and a multipurpose room as well as the necessary restrooms and storage spaces (see Appendix for program sizes). It is located on the top of Breeds Hill in Charlestown, Massachusetts, on the southeast corner of Mead Street and Bunker Hill Street. The site has a southwest to northeast orientation perpendicular to the slope of the hill with due-south running diagonally across the site. The hill itself drops off sharply at the southern third of the site. The site also has a view of downtown Boston to the south, and the Charles River to the west.

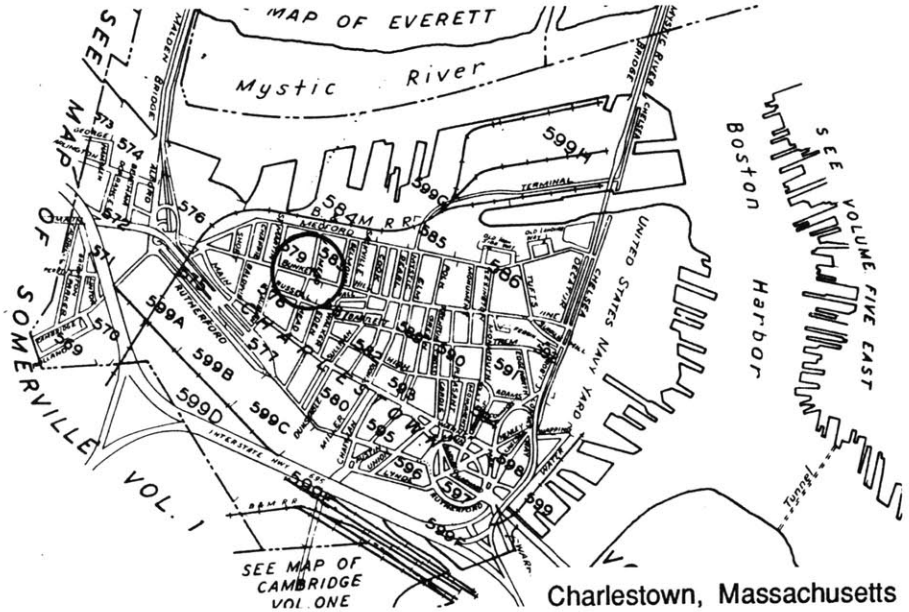


Final design model



Regional Context

1. Charlestown
2. Boston
3. Boston Harbor
4. Charles River
5. MIT



Charlestown, Massachusetts

Some of the intentions for the design were:

- that light should help organize the design and hence assist one in understanding the three-dimensional space, providing clues to movement and stopping spaces within.

- that light should be present above in some connection with the sky

- that the opportunity should exist to experience the change in light during the daily cycle of the sun

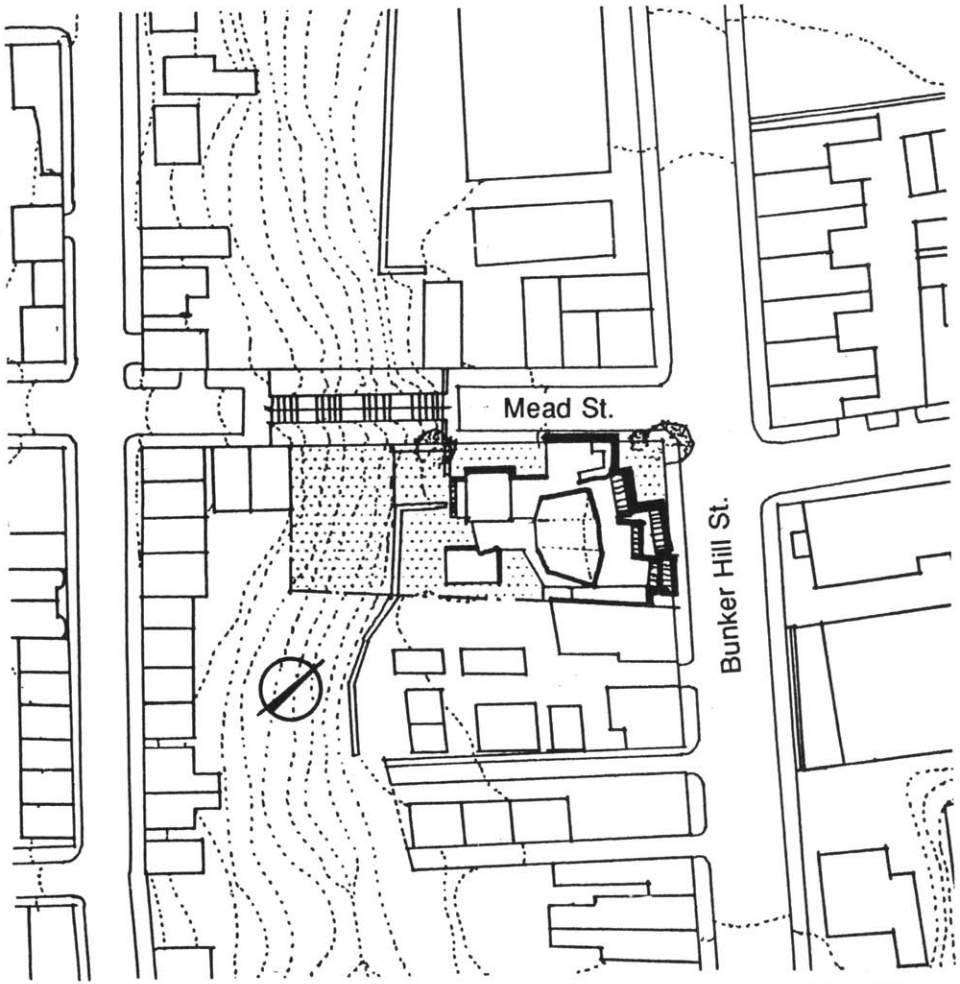
- that light should identify the larger collective spaces of the school

- that natural light should exist in the work areas, but that it should be controlled in terms of its direction, orientation and intensity.

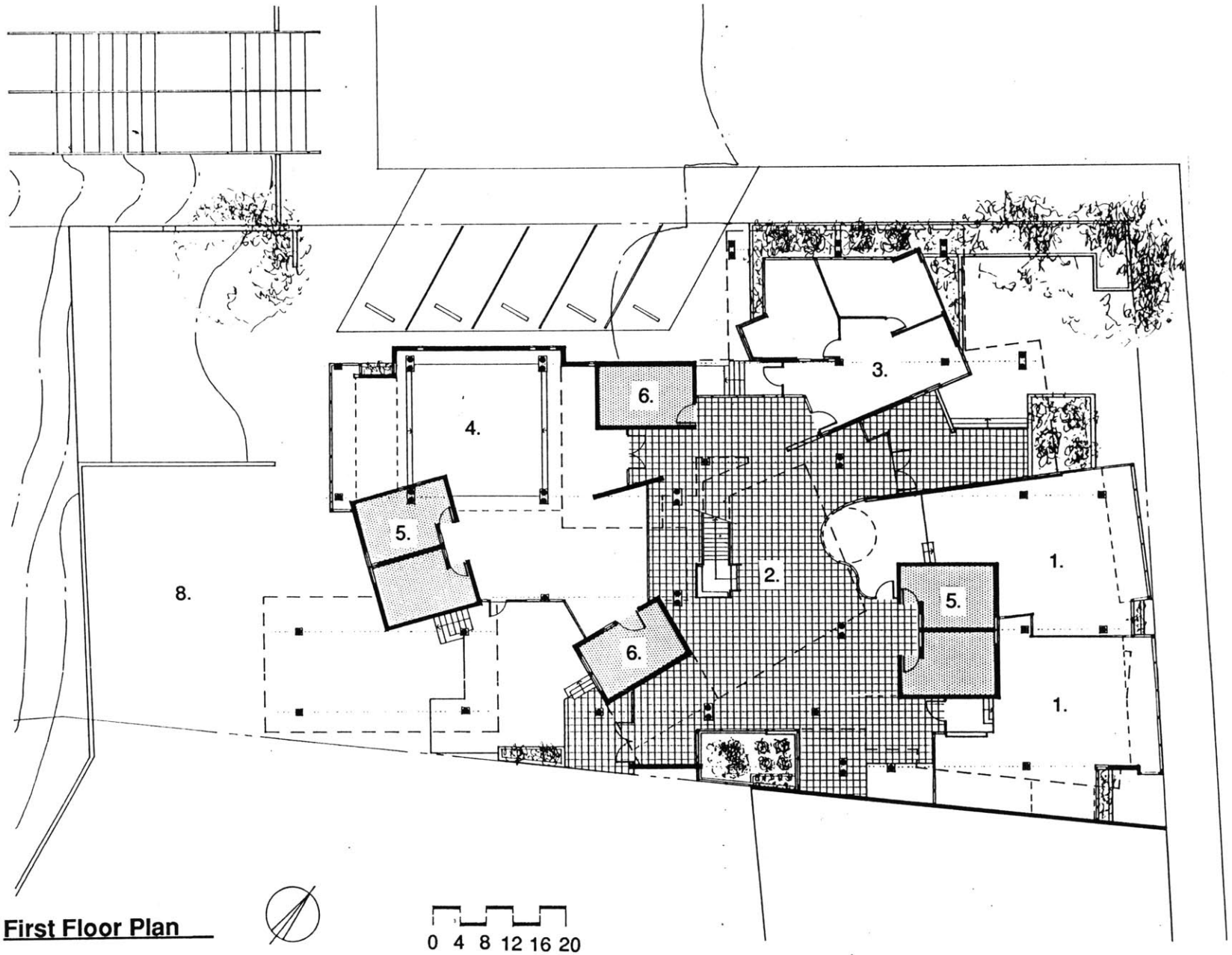
- that the materials, closure screens, and structure should all enhance the understanding of light being in and moving through the building.

The design section for this thesis is considered the vehicle for testing some of the principles about the light and form relationships that have come from studying the light references. The design mostly focuses on generating the five categories of light phenomenon: light as continuity, light as structure, light as a connection, the relation of light and screens, and light as a containment.

Because of this need to advocate light as the primary generator of the design, certain other aspects such as the steeply sloped part of the site and the view were not dealt with in the design. Also, the goal was not so much to produce a buildable design as it was to push the notion of light as the design generator.

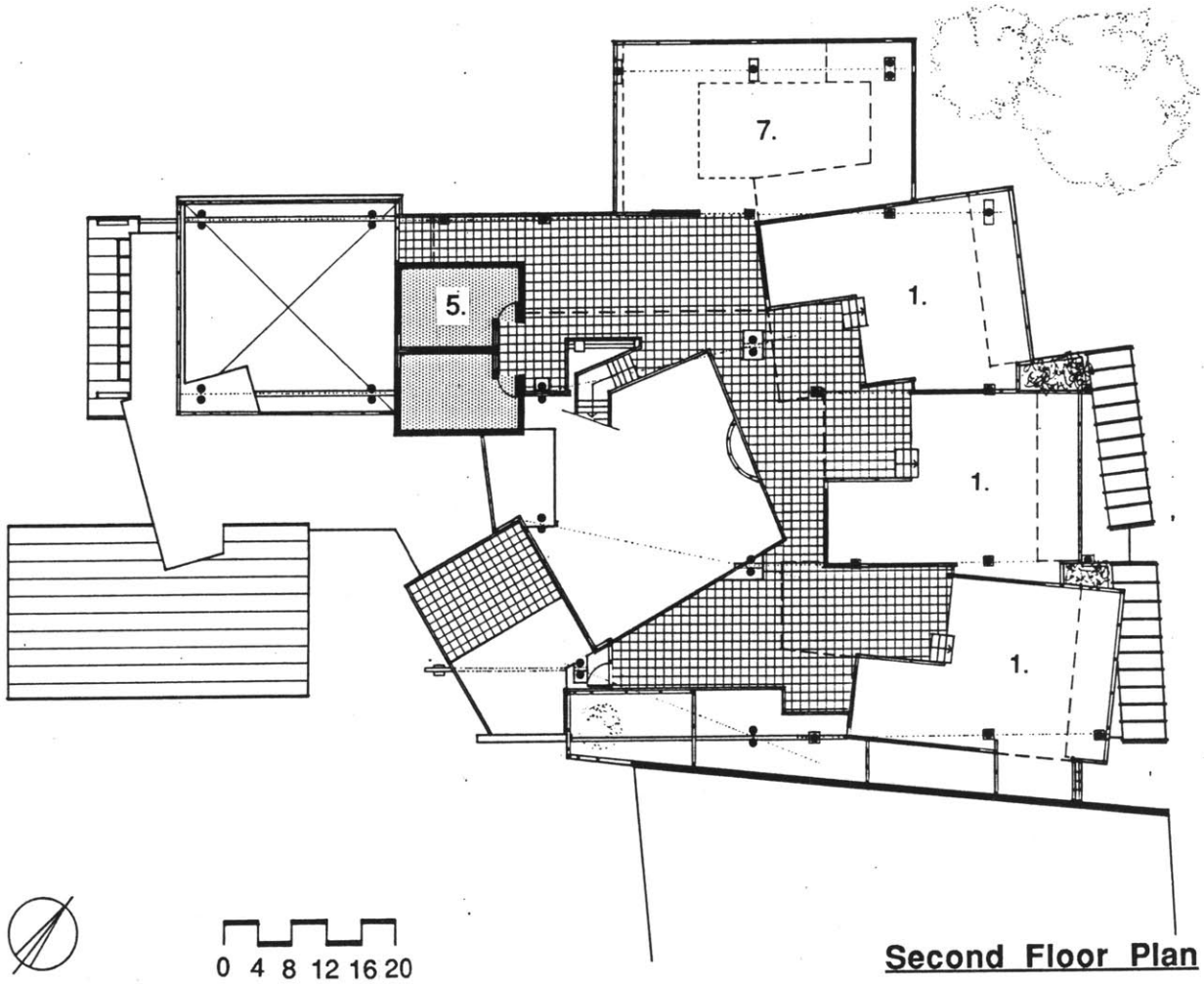


Site Plan

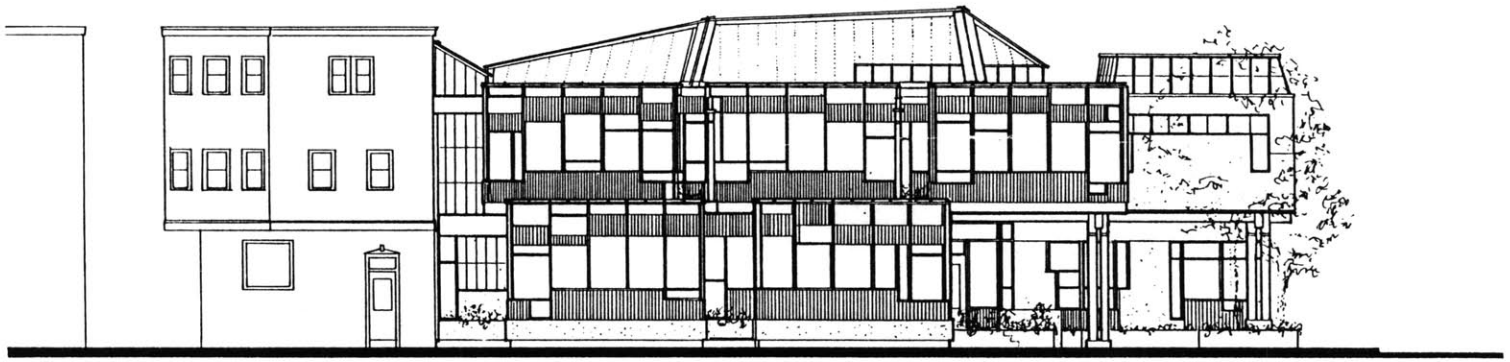


First Floor Plan

1. Class rooms
2. Central space
3. Offices
4. Multipurpose Room
5. Restrooms
6. Storage
7. Library
8. Playground



Second Floor Plan

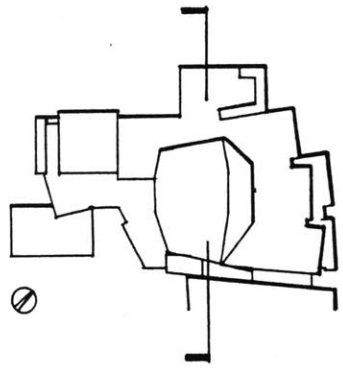


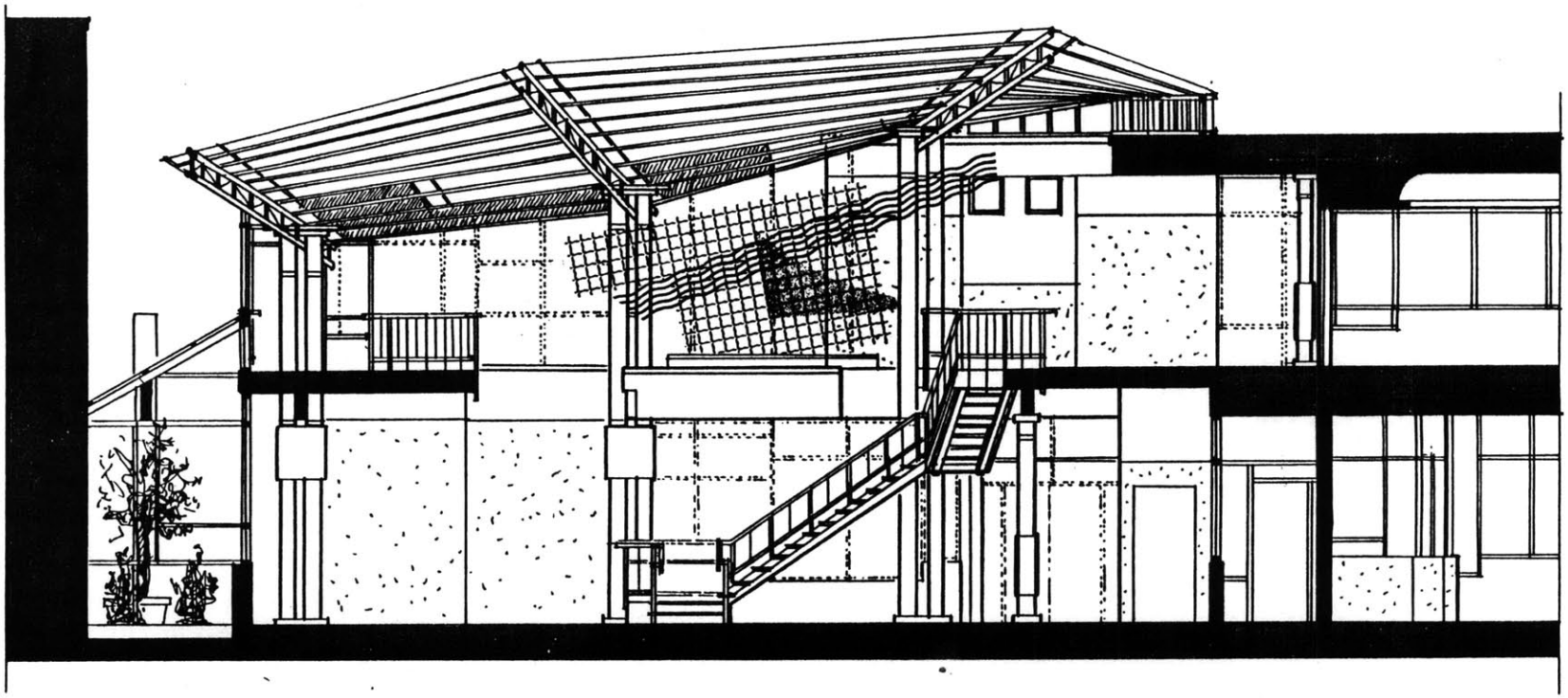
0 20

Bunker Hill Street Elevation

0 20

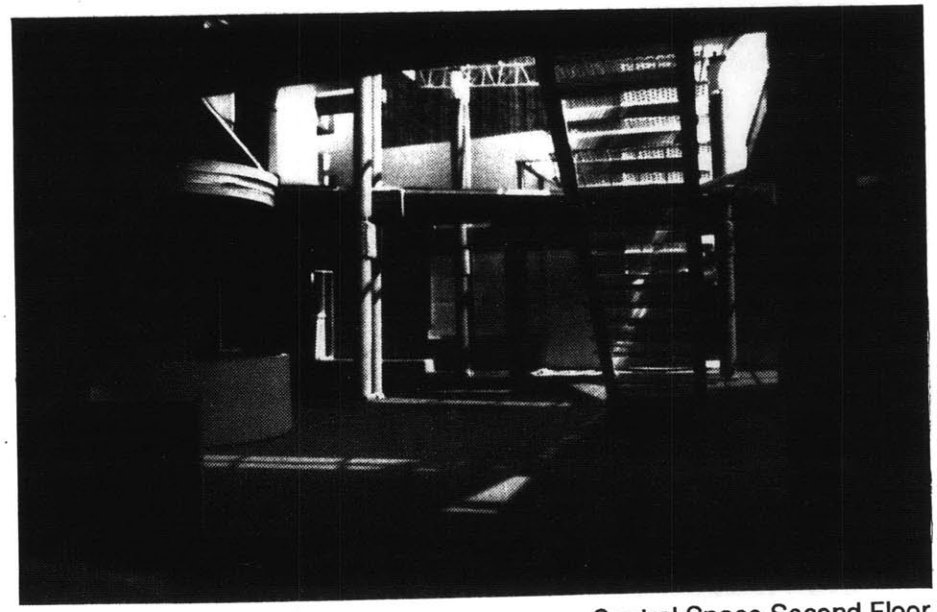
Mead Street Elevation





Section Through Central Space

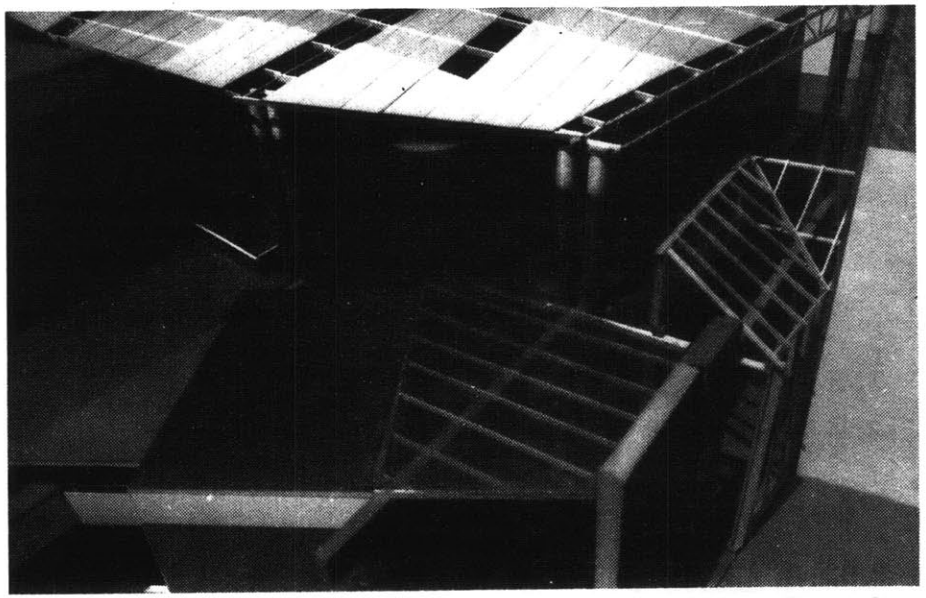
Central Space First Floor



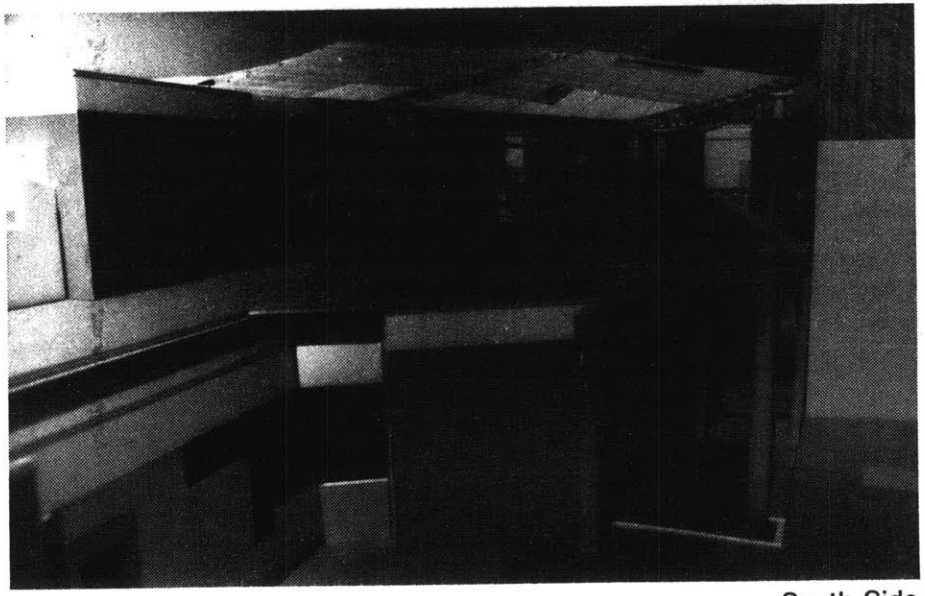
Central Space Second Floor

Main Entry

Decorative Screen in Central Space

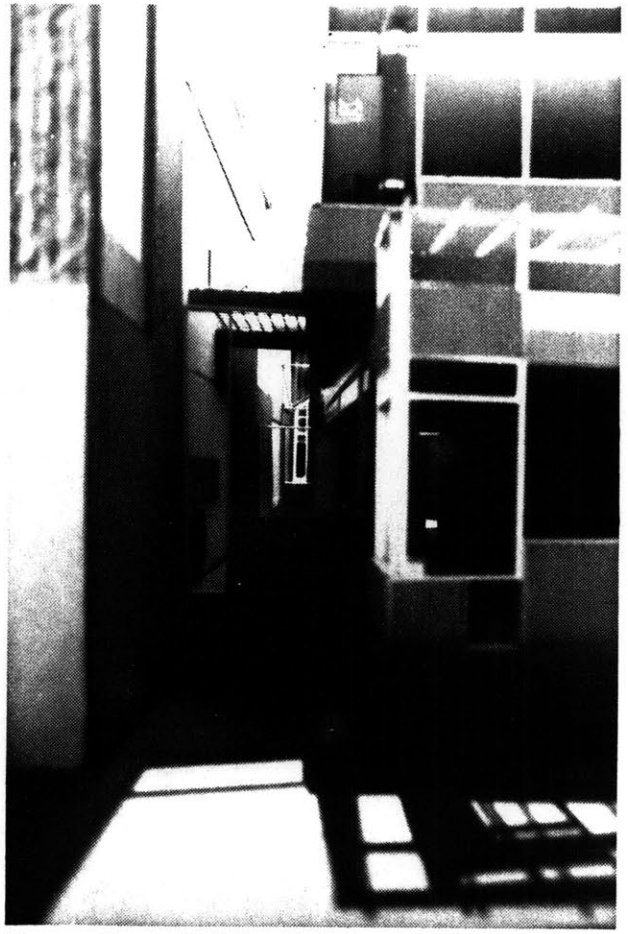


South Side

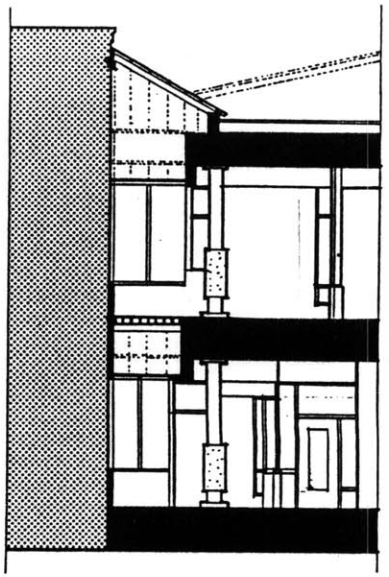


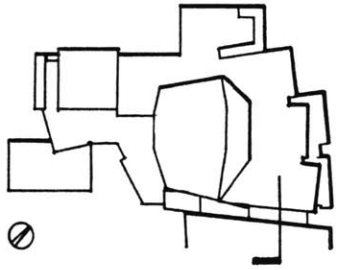
South Side

Connection to Existing Building Second Floor

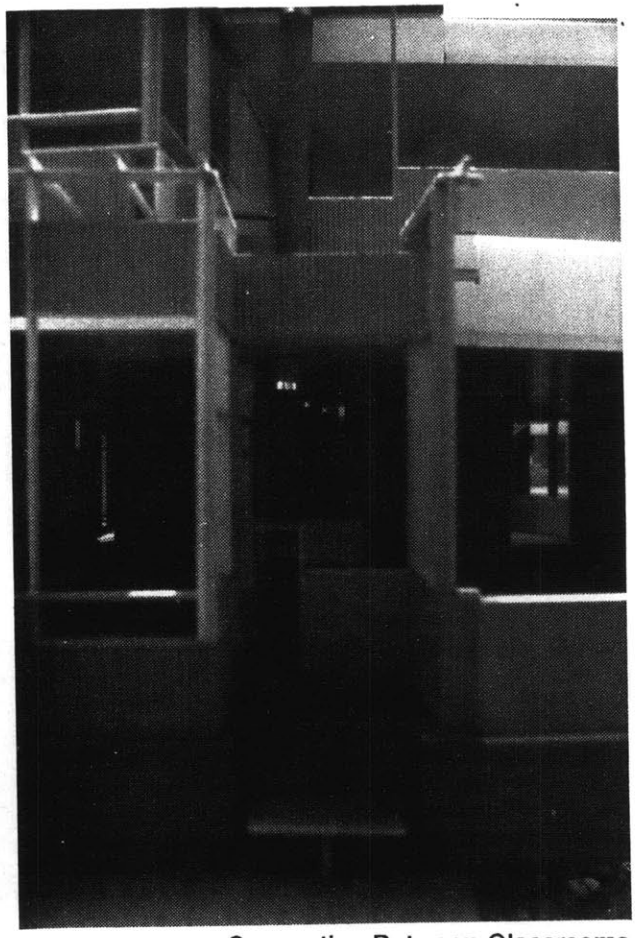


Connection to Existing Building First Floor



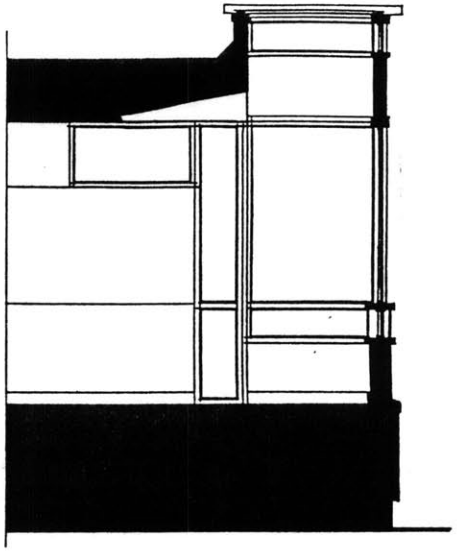


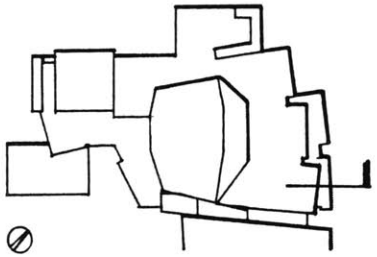
Playground Entrance

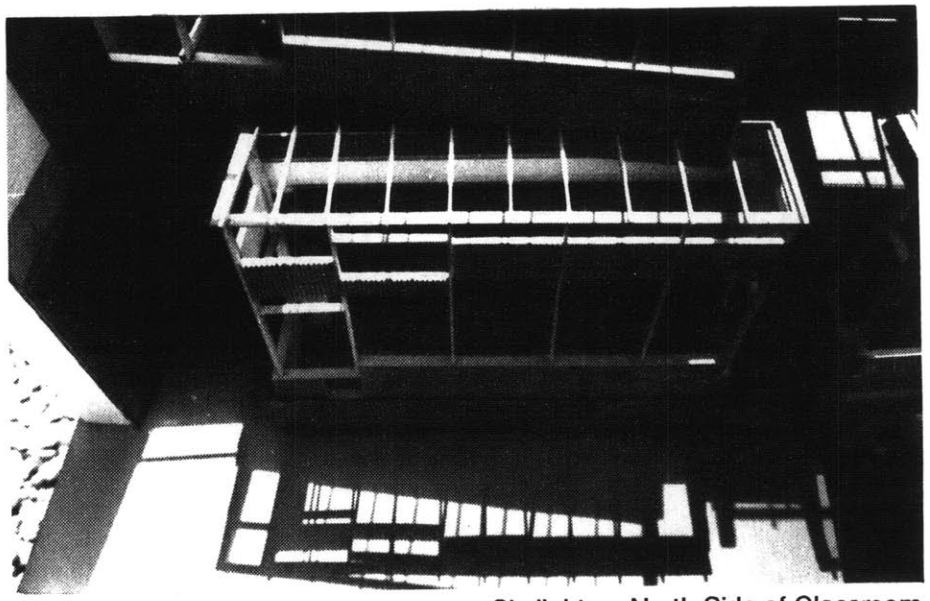


Connection Between Classrooms

Skylight on North Side of Classroom

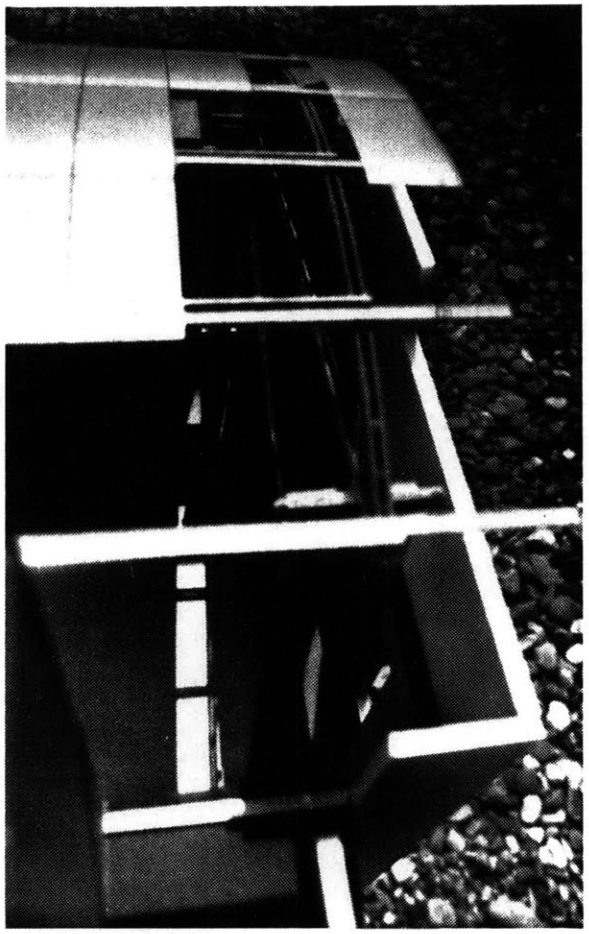




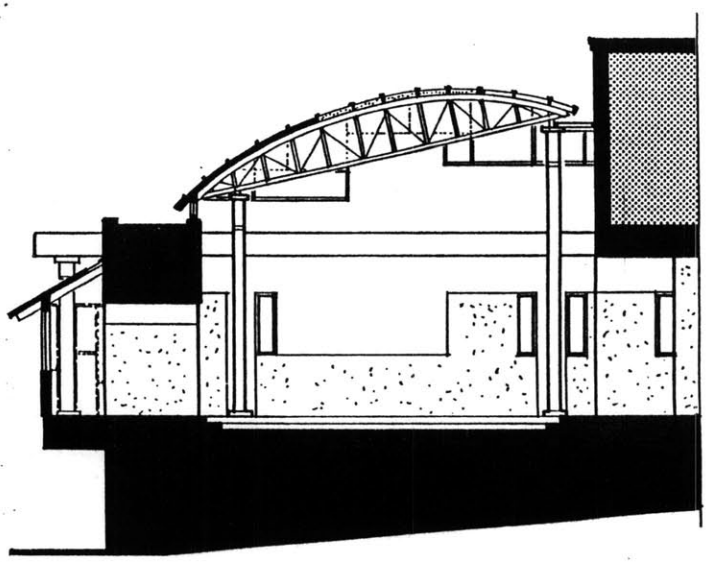


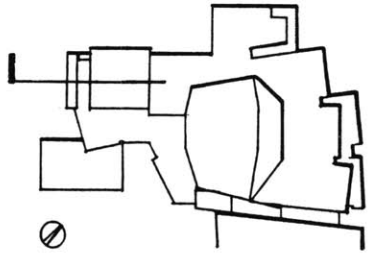
Skylight on North Side of Classroom

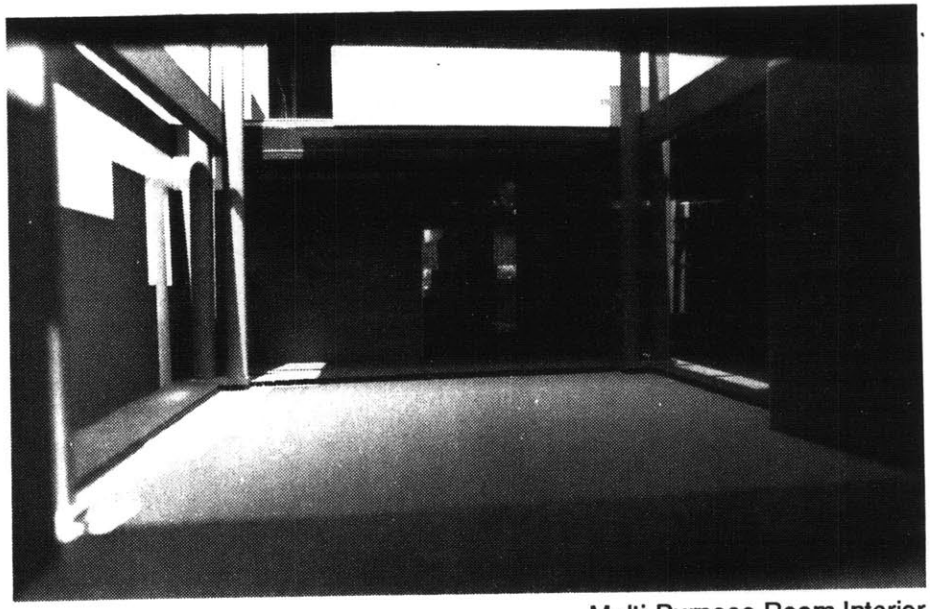
Skylight on North Side of Classroom



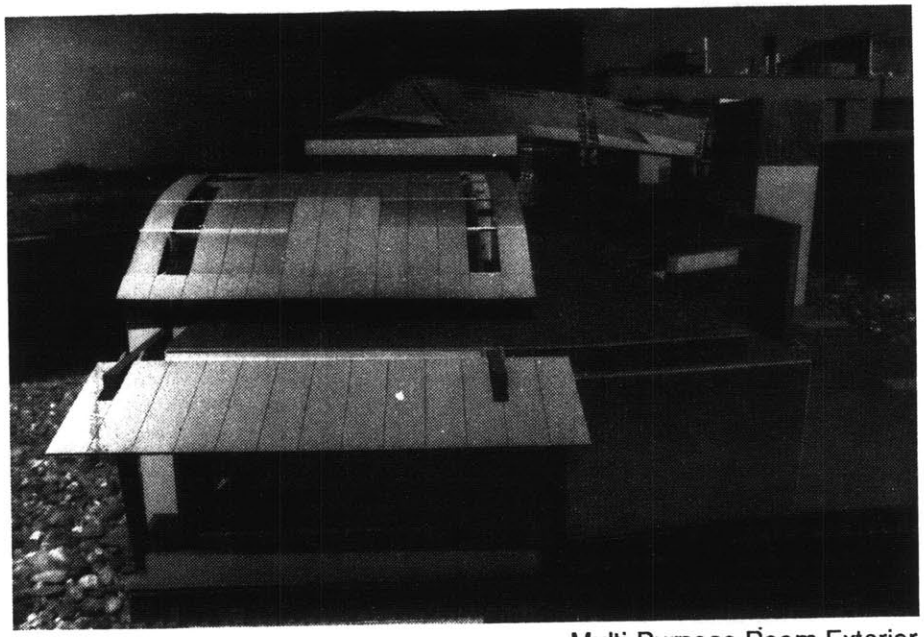
Multi-Purpose Room







Multi-Purpose Room Interior

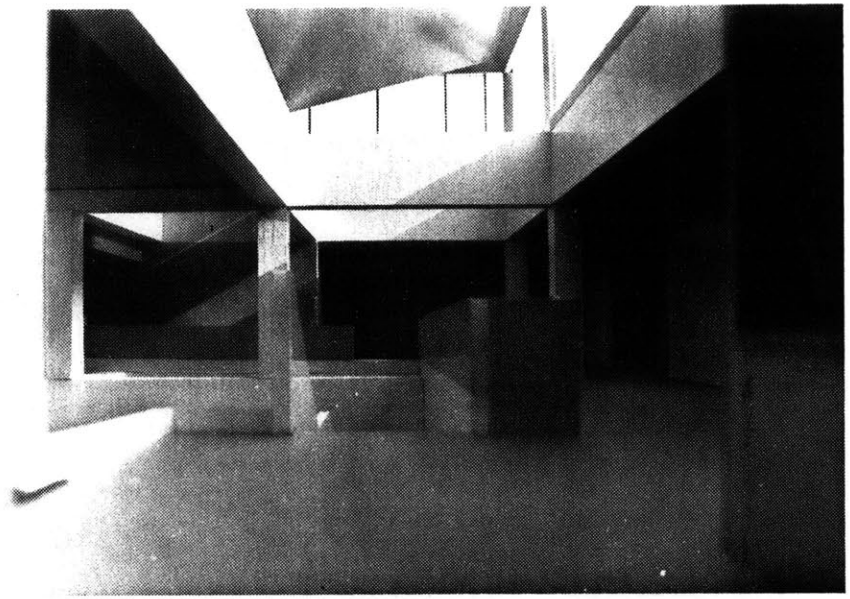


Multi-Purpose Room Exterior

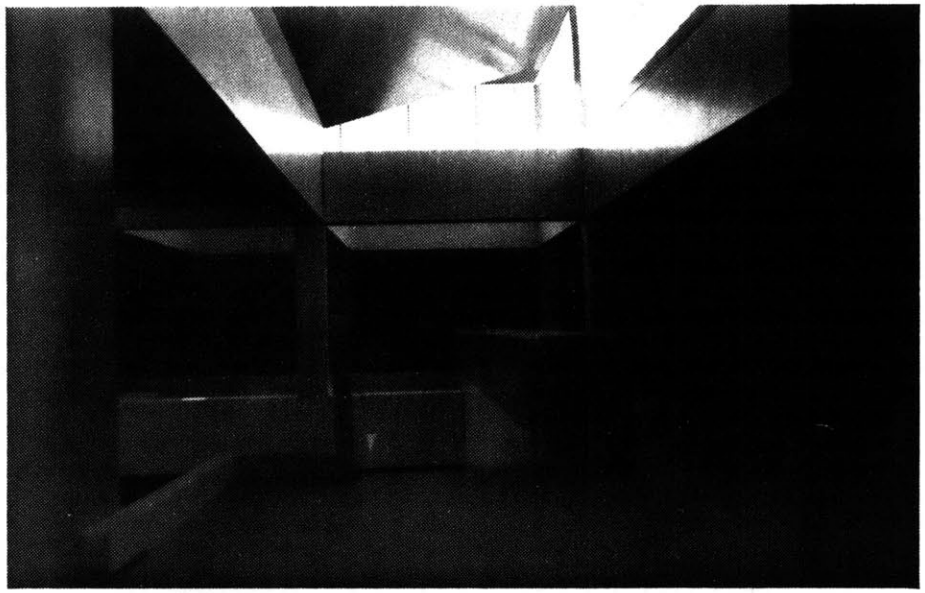
"This quiet morning light reflected, how many times from grass and trees and clouds enters my north room touching the walls with grass and clouds and trees."

- William Carlos Williams

ill.13



Upper Floor - Winter



Upper Floor - Summer

Model Reference:
Additions to Don Bosco High School

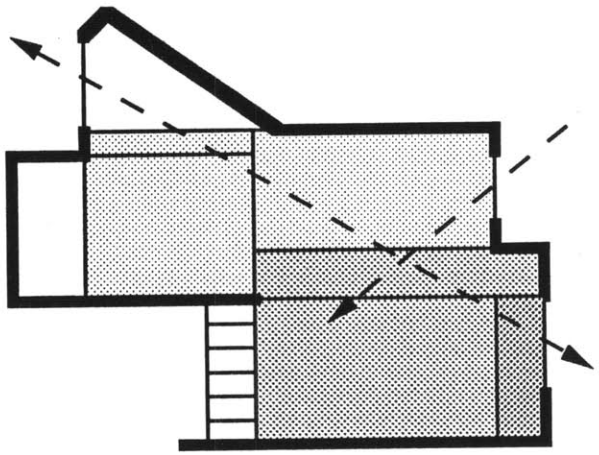
Collective dining space for private apartments
Boston, Massachusetts Latitude 42° North
Imre and Anthony Halasz, Inc., 1985

The top two floors of the Don Bosco High School Addition house the monks who teach at the school. The living quarters are arranged with private apartments and a chapel above; the kitchen and living room below. These spaces are connected by a large double-height collective space.

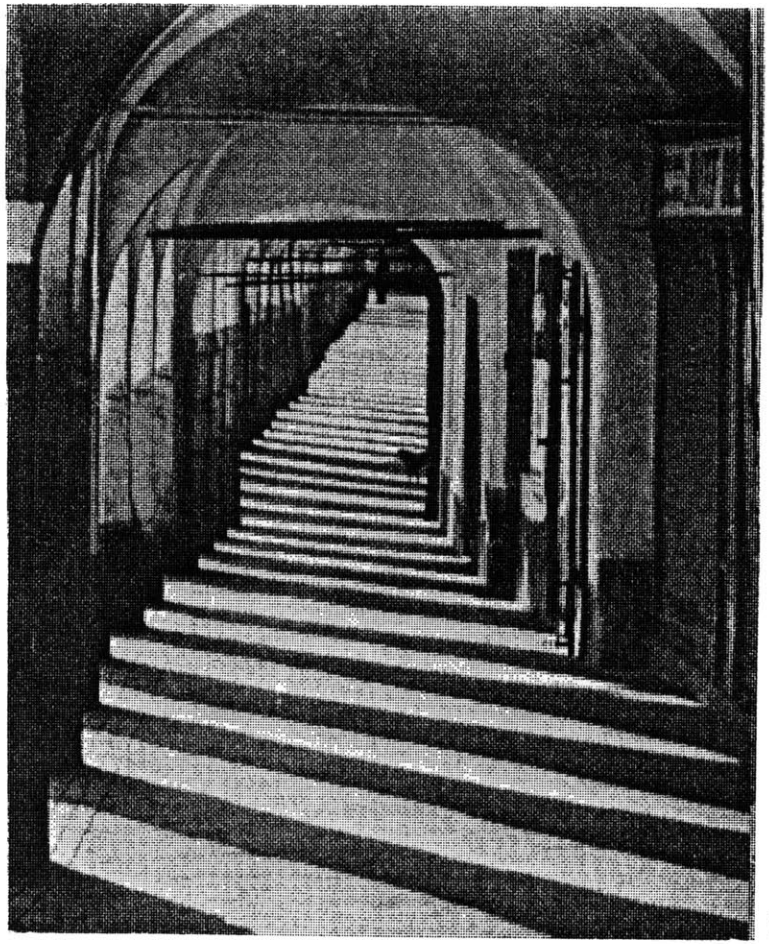
The entry is located at the northwest corner of the collective space on the lower level. A series of punched windows along the north wall establish a rhythm of light and dark from the entry into the collective space. Four columns and overhead beams loosely define the room's east and west sides. Moving diagonally across the room to the stairs, the ceiling steps-up to build the diagonal in section. Moving up the stairs, the ceiling steps-up again into the skylight allowing light in from above. A clerestory window on the north side of the collective space, opposite the skylights, allows light to be continuous through the diagonal section. The

skylight continues the stair direction and becomes part of the small chapel on the west side of the top floor. In the other direction from the chapel, the skylight turns perpendicular to the stair and contains the collective space.

The glazing materials in the skylight are panels of Kalwal, a translucent material. These panels are framed by clear windows adjacent to the columns. The Kalwal, diffuses the light and gives it a warm tone while the clear glazing offers glimpses of the sky. The angled ceilings in the skylight are painted bright yellow which reflects the light down and add more warm color to the light. The wall surfaces are painted a two-tone color scheme of off-white and beige that picks up the color of the light, and is applied so as to give clues about the structure of the space.



Diagramatic setion of Don Bosco showing continuity of light through the section.



ill.14

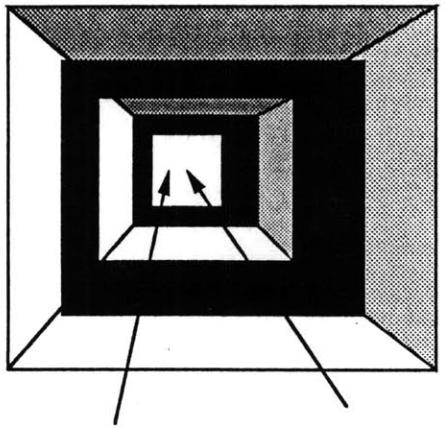
Rythmic alternation of light and dark builds direction of movement.

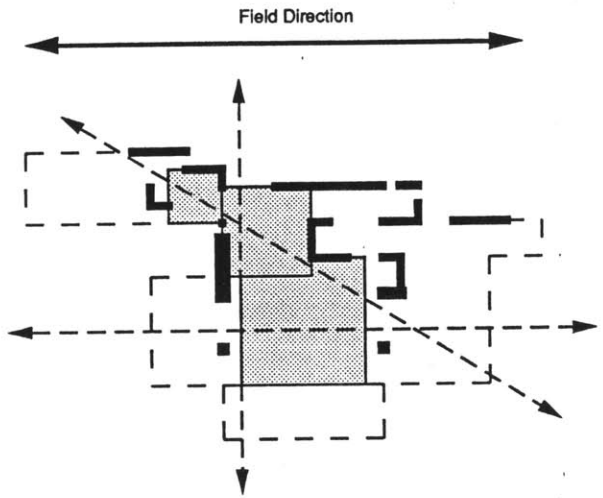
"A good forest is trees-light-trees-light.
A good building should be the same."

- M.K.Smith

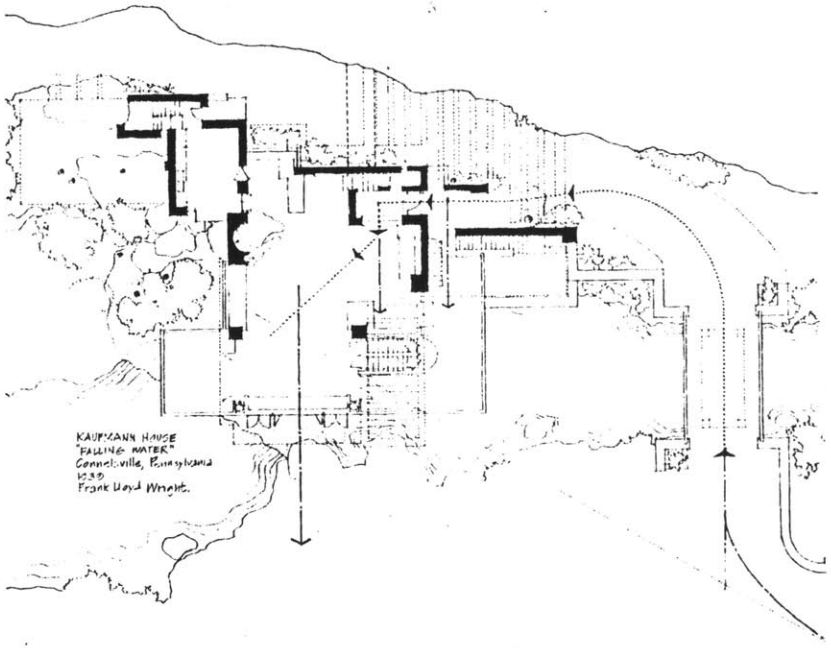
Light As A Continuity

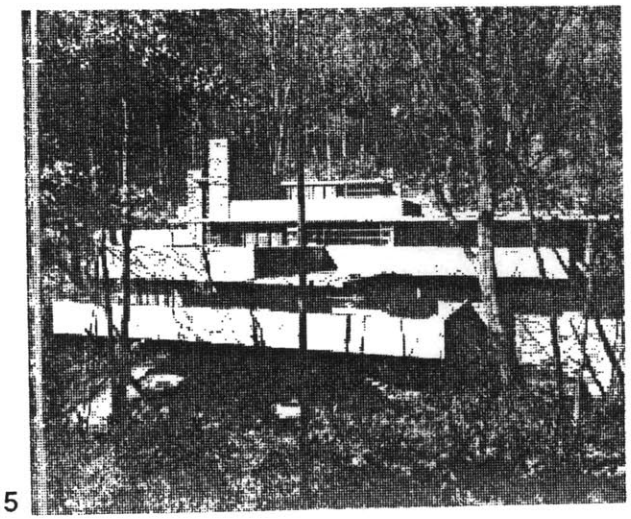
The phenomenon of light as a continuity in architecture can exist in two ways. One is when light "moves" through space uninterrupted. This can reinforce a direction, provide a zone of registration, and/or unify several spaces into a larger whole. Continuity can also be generated by the alternation of light with dark. This often builds movement in some direction. For example, the rhythm of shadows and sunlight along an arcade of columns builds the direction of the street. At a larger scale it could be the distribution of solid walls or rooms within a larger field of continuous space that establishes zones of light and dark across the field. The following is a sampling of references that display this phenomenon of continuous light.





Dark pieces are organized to provide a range of containment from more defined to less defined. As containment becomes less defined , spaces becomes lighter. Light also is allowed to pass accross the field connecting the various spaces into a whole.





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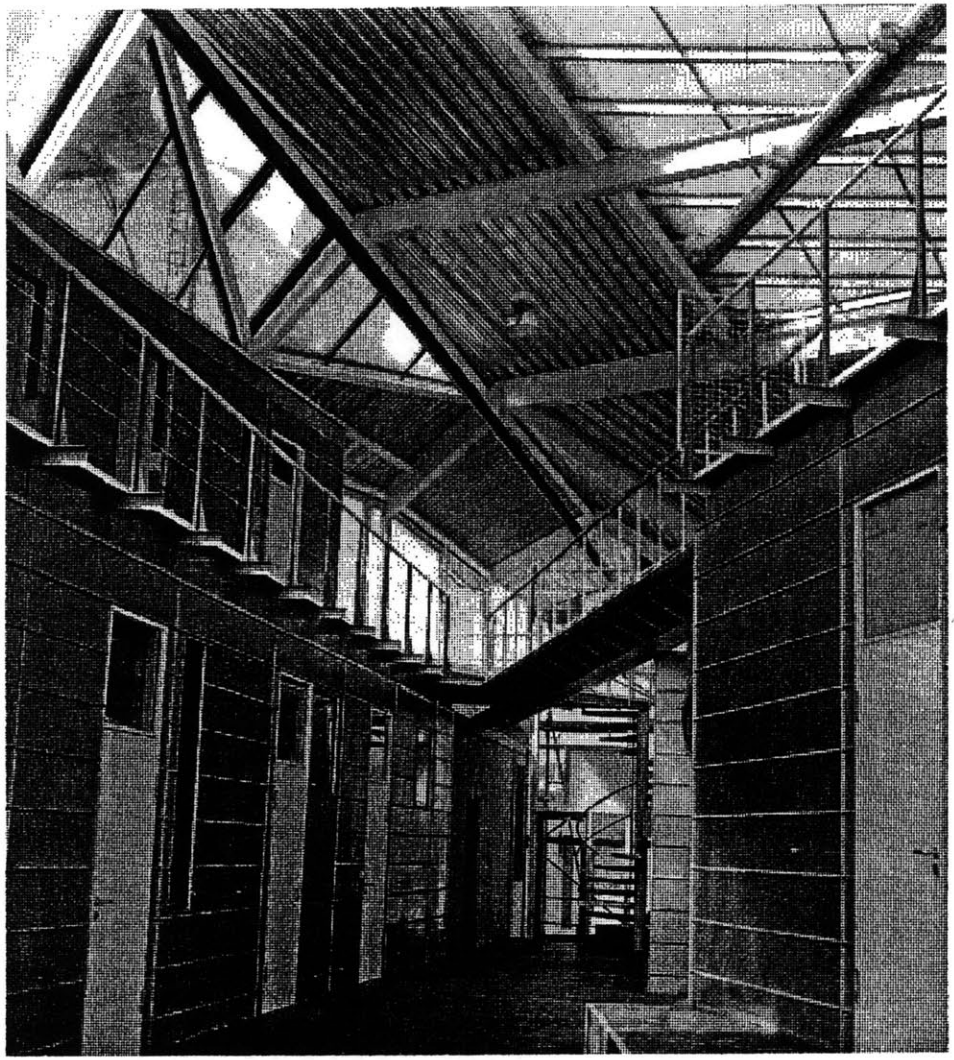

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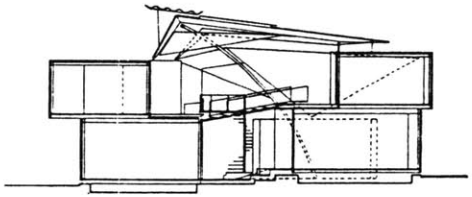
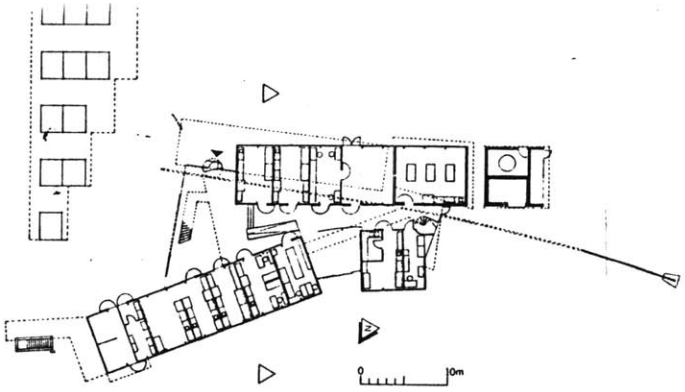
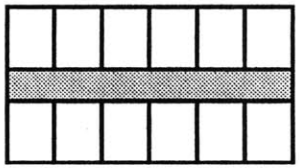
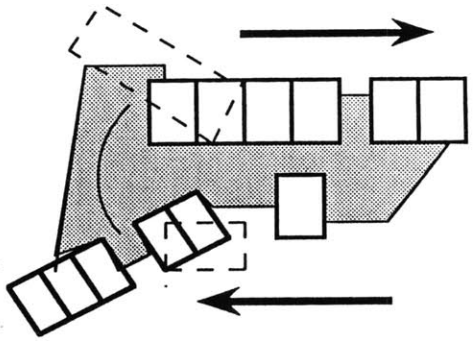


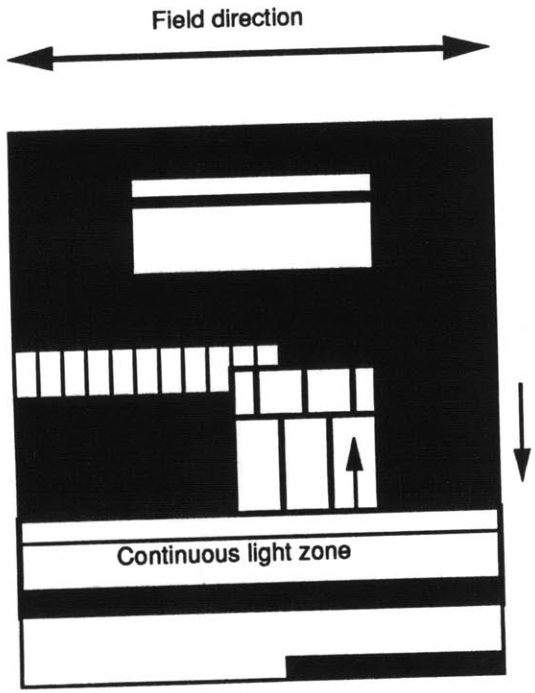




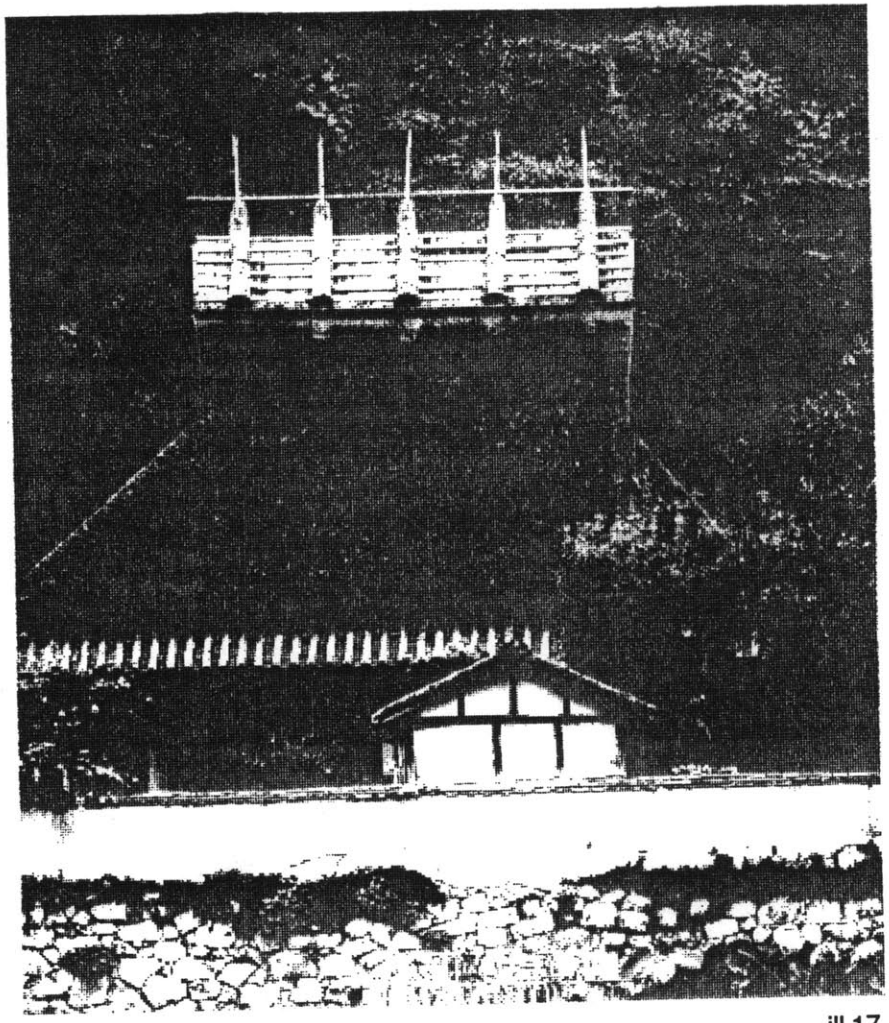
Typical double-loaded corridor, privacies packed together



Shift occurs and privacies break into smaller groups allowing more access to light. Rotation opens collective spaces up to southern exposure.



Continuous zones of light and dark build the direction of the field. Small building generates a recipricol ex change in the middle. Also some of each zone gets deployed in the other, reinforcing the exchange. Articulation in the roofs help build direction as well.



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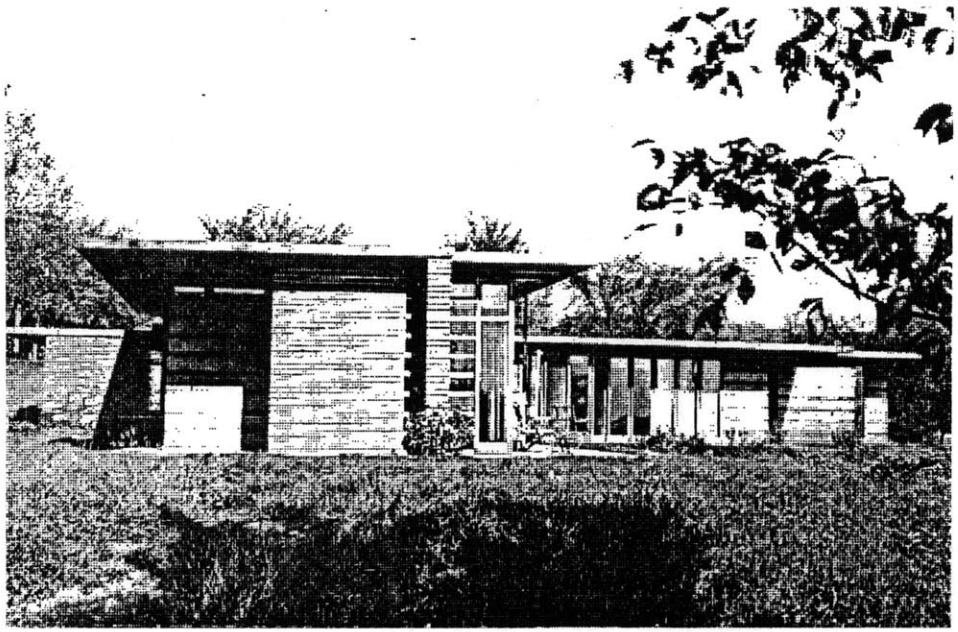

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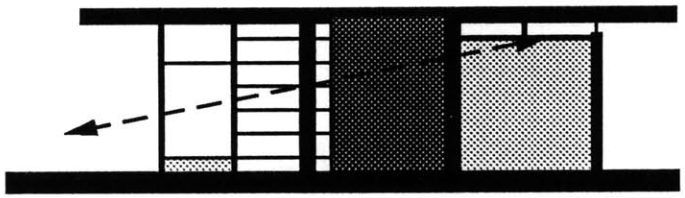
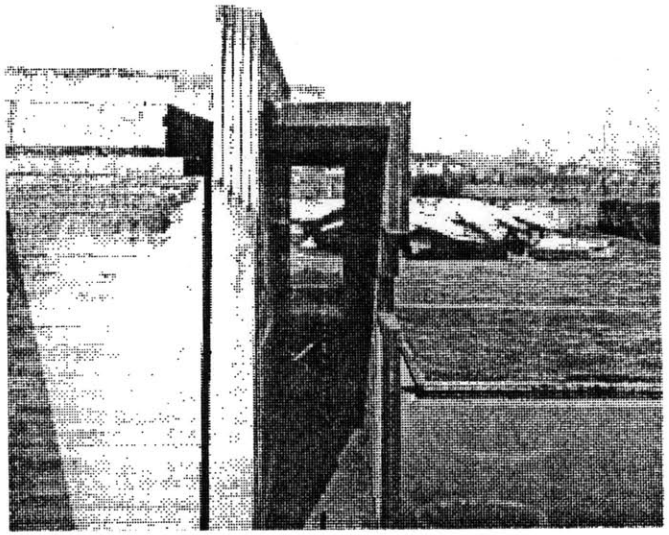


Light zone at the ceiling "supports" the roof. Light also penetrates between the heavy masonry walls. Light is continuous through the building.



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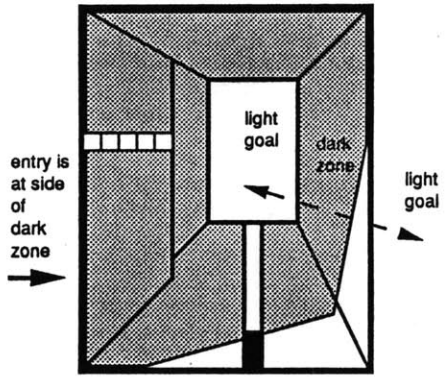
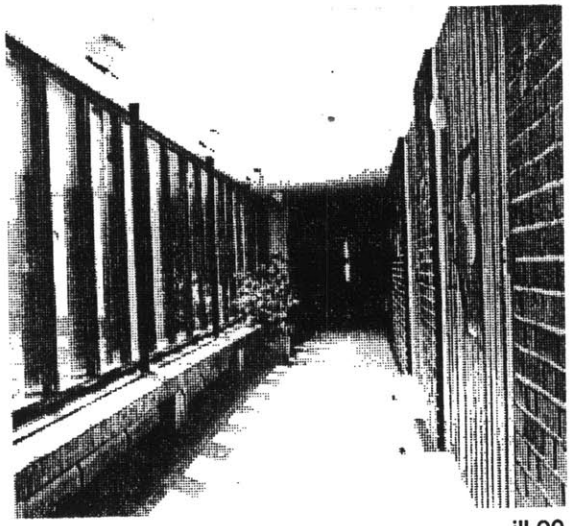


Metal strips in the floor surface provide continuous light through dark entry zone; reverses to dark in the sun. Wall tiles also function in the same manner.



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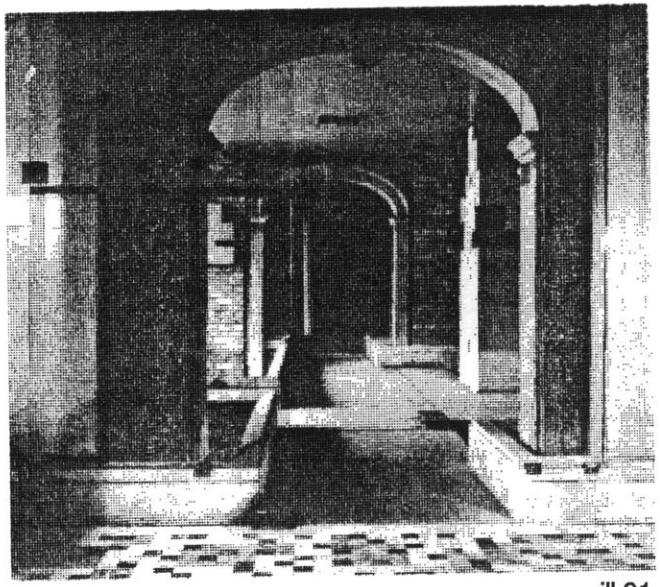

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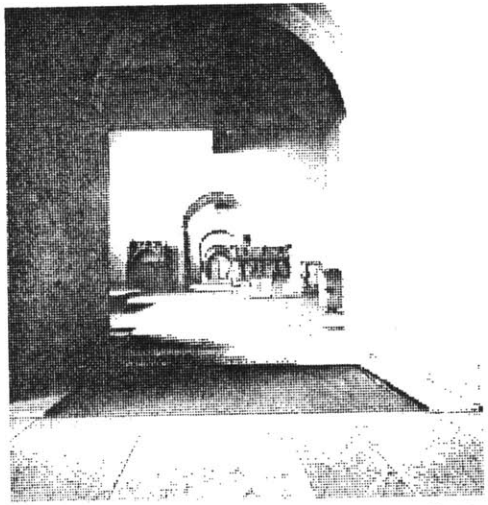

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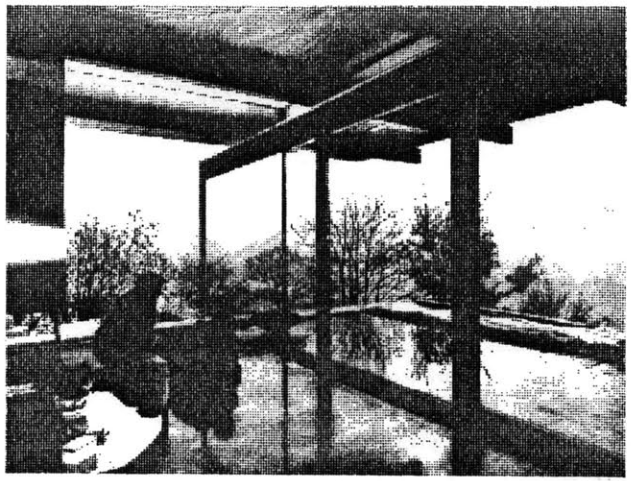

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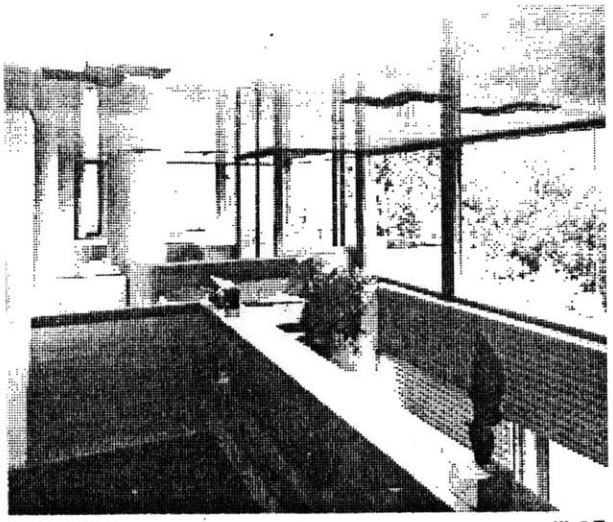

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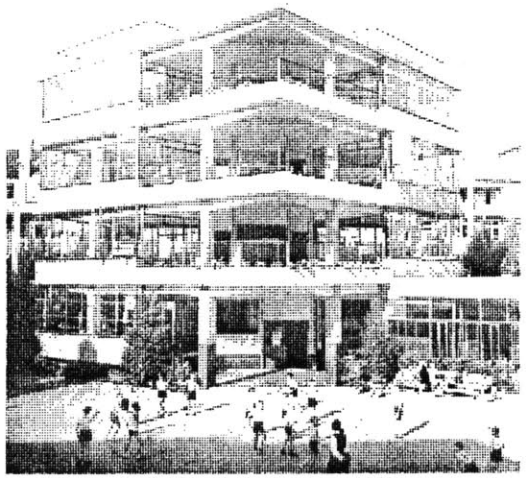

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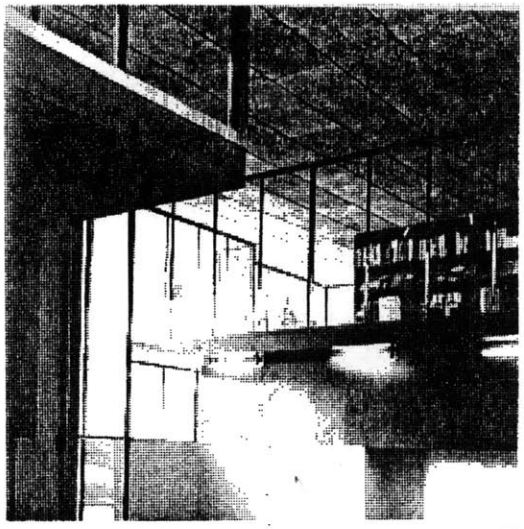

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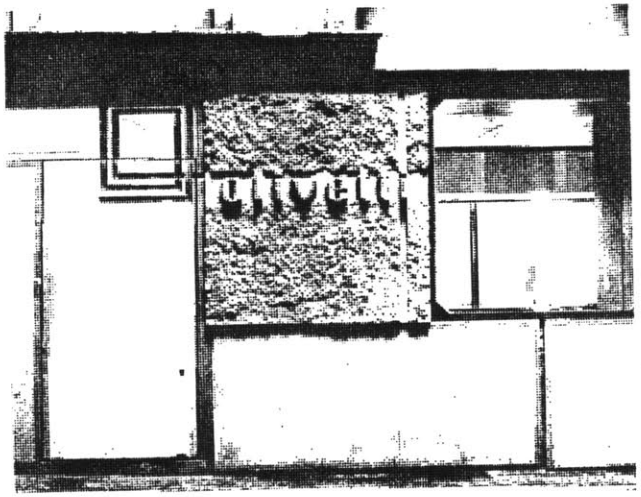

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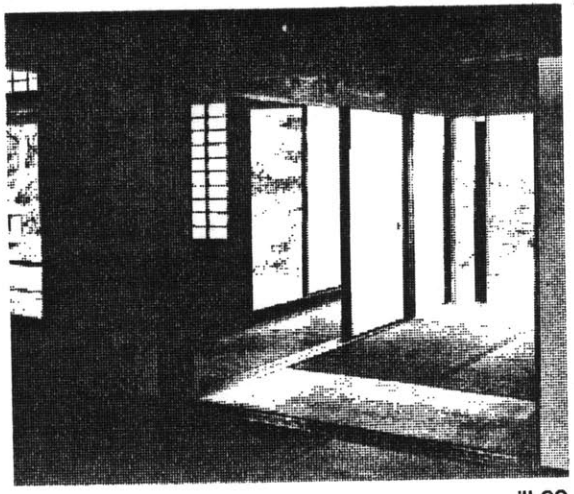

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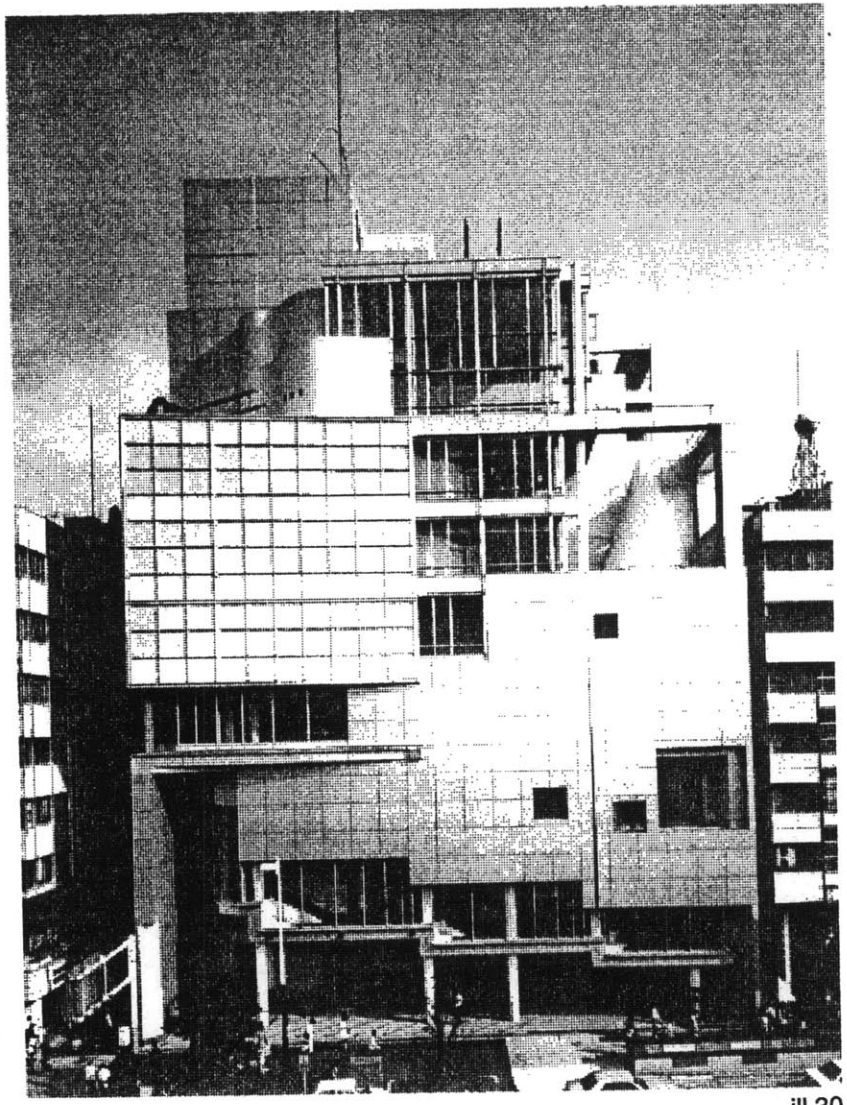

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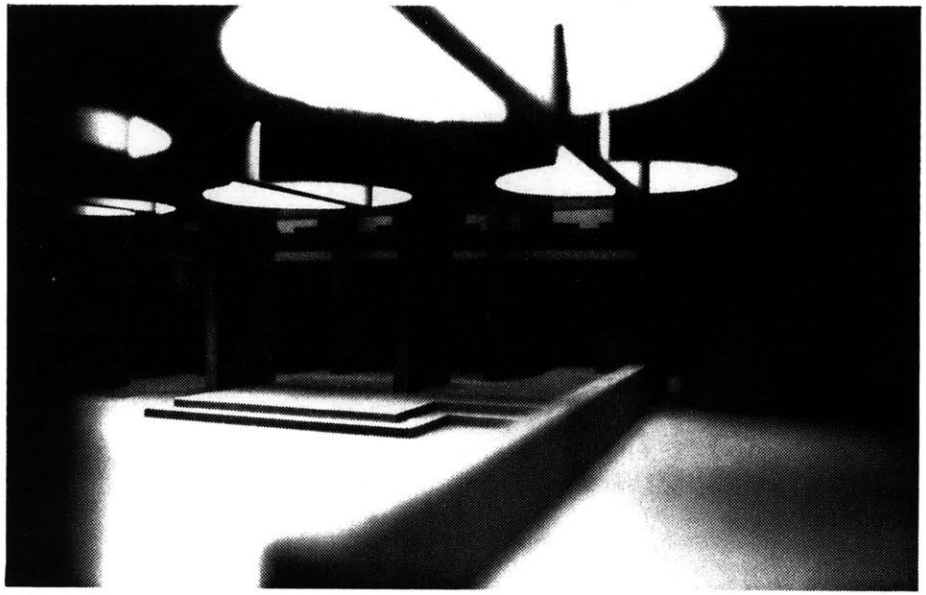
"Gothic-like" Space



"Crypt-like" Space

Model Reference:
Pastoor van Ars-kerk

Roman Catholic Church

The Hague, The Netherlands Latitude 52° North

Aldo van Eyck , 1971

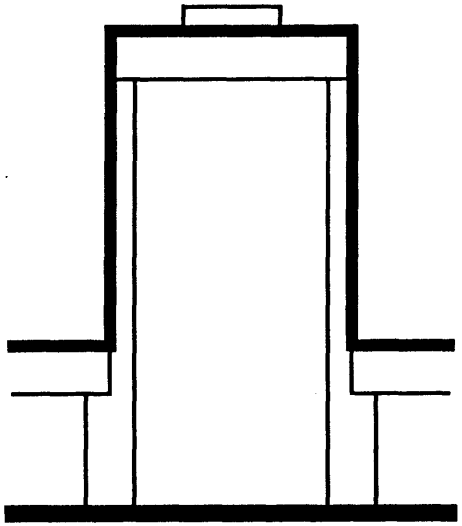
The exterior shape of Pastoor van Ars-kerk is a small rectangle. Entry occurs where two of the circular chapels bulge out through the exterior wall. Once inside, the main access is along the tall narrow (3 meters x 11 meters) "via sacra" which runs horizontally across the entire width of the church. This space provides access to and from the low seating area (3 meters high). Van Eyck's intentions were,*"to combine the quality of a low crypt-like space with that of a tall gothic-like one."*

This building is noteworthy because of the way light works with the structure. All the light in the two spaces is from above through circular concrete drums. Rather that being a circle cut in the roof, the drums' depth focuses the light, sending most of it straight down. The drums are not located in the typical neutral position between the roof beams, but are instead located directly on top of the beams. This generates an alternating pattern of light and dark that

overlaps with the structural grid. The drums are also notched where they connect to the beam allowing some light to spill out along the beam.

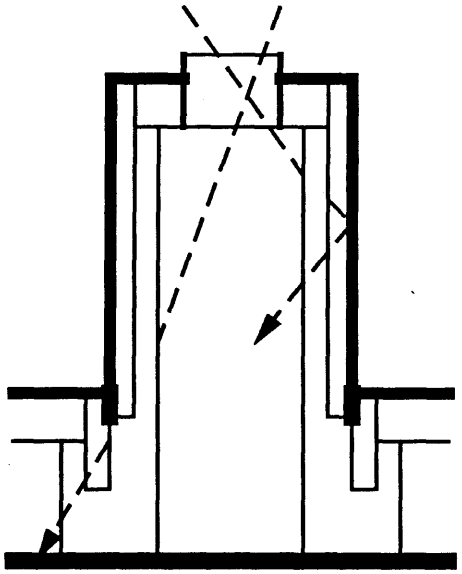
The way the columns relate to the the walls is also noteworthy. Instead of attaching the columns to the wall or completely incorporating them into the wall, Van Eyck pulls them away from the wall allowing light to pass between. This is intensified where the structures of the two spaces join.

Van Eyck also incorporated light into the beam structure that supports the upper walls of the tall space. He understood that the bending stresses in a beam are greatest at the top and bottom edges, and was able to create a beam section with space, and therefore light at the center of the beam.



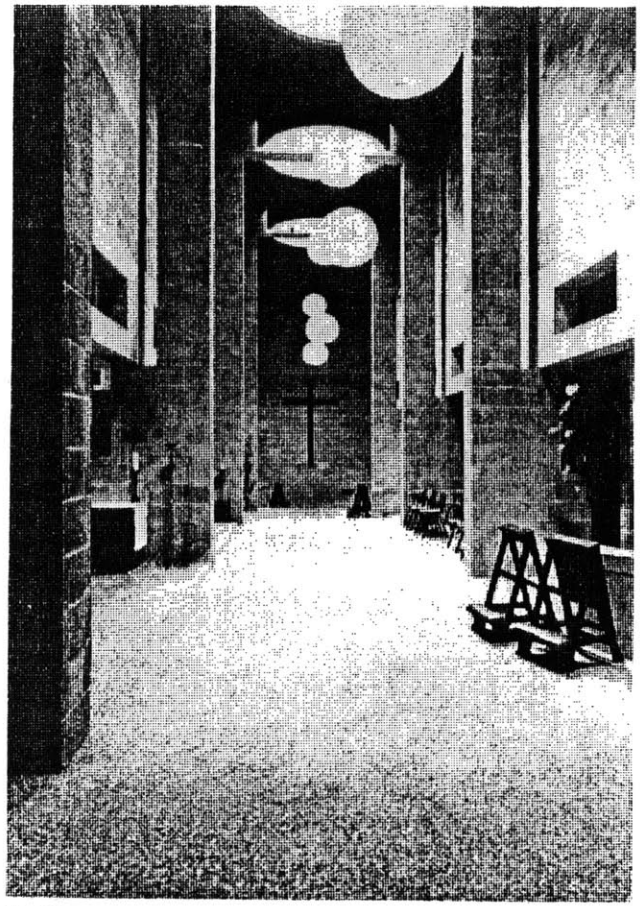
The Standard Approach:

Walls and structure are conincident with each other.



The Transformed Version:

Structure sits away from wall allowing light to be continuous between the two. Skylight drum stradles the beam allowing the beam to be in the light.



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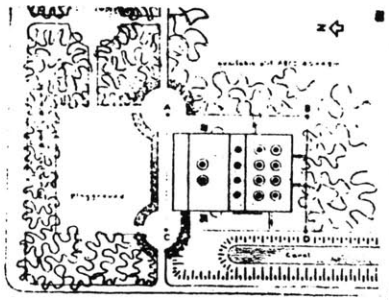

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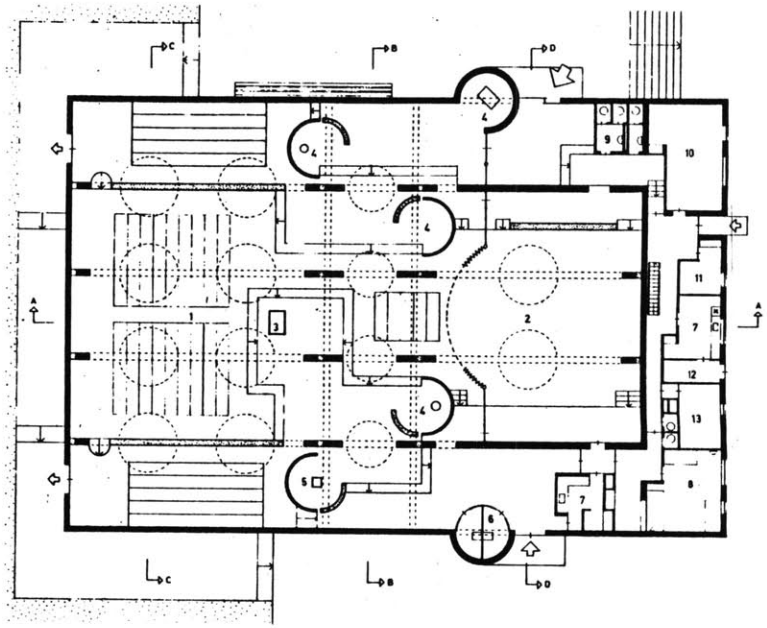

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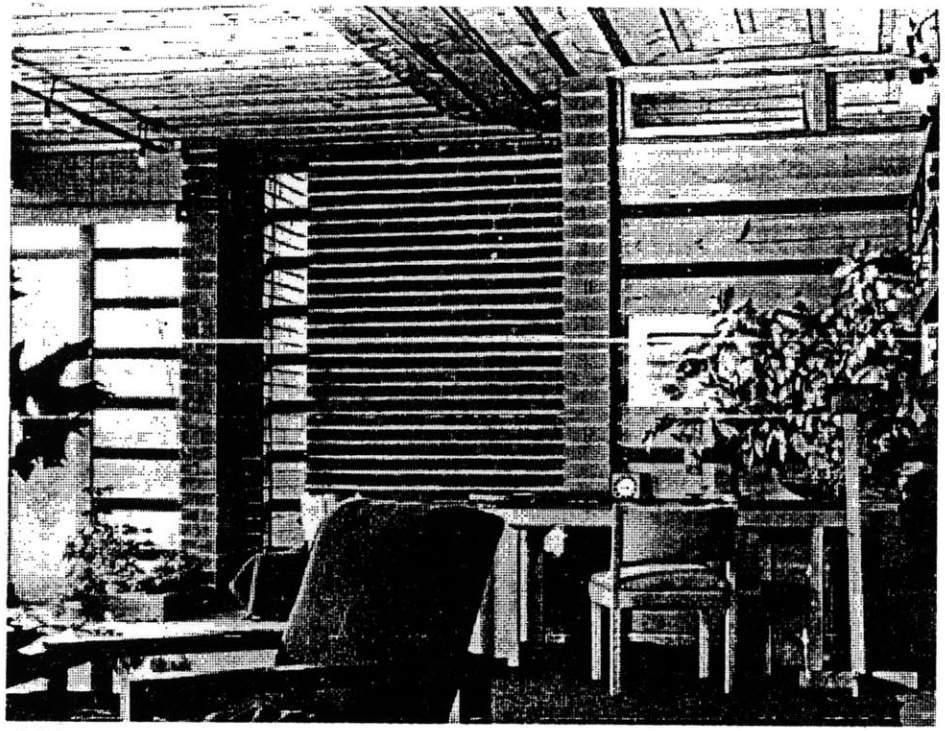

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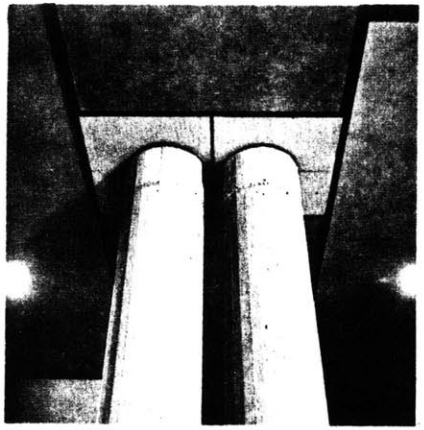

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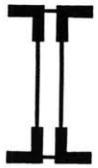
Light As Structure

The phenomenon of light as structure can occur on two different levels. One occurs when light is allowed to penetrate through the center of gravity of the structural support, or when light exists where traditionally solid support was required. For example, due to the ability to cantilever beams, the corner of a space can be open allowing light to dematerialize the edge of containment. Light can also surround the structure, highlighting it, making it a source of light in the space. For example, in the Van Eyck church presented previously, the skylights are placed over the beams allowing the beams to play an active role in lighting the space. The following is a sampling of references that display this phenomenon of light as structure.

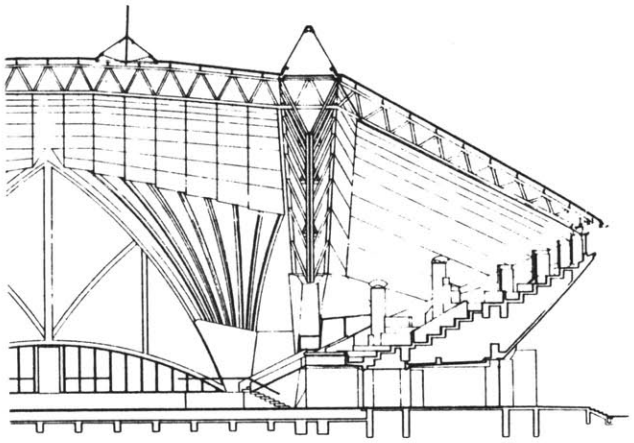
Pre-19th c.

19th c.



20th c.

Advances in knowledge about the structural behavior of the bending stresses in a beam has allowed for a section where space, and hence light , is at the center.



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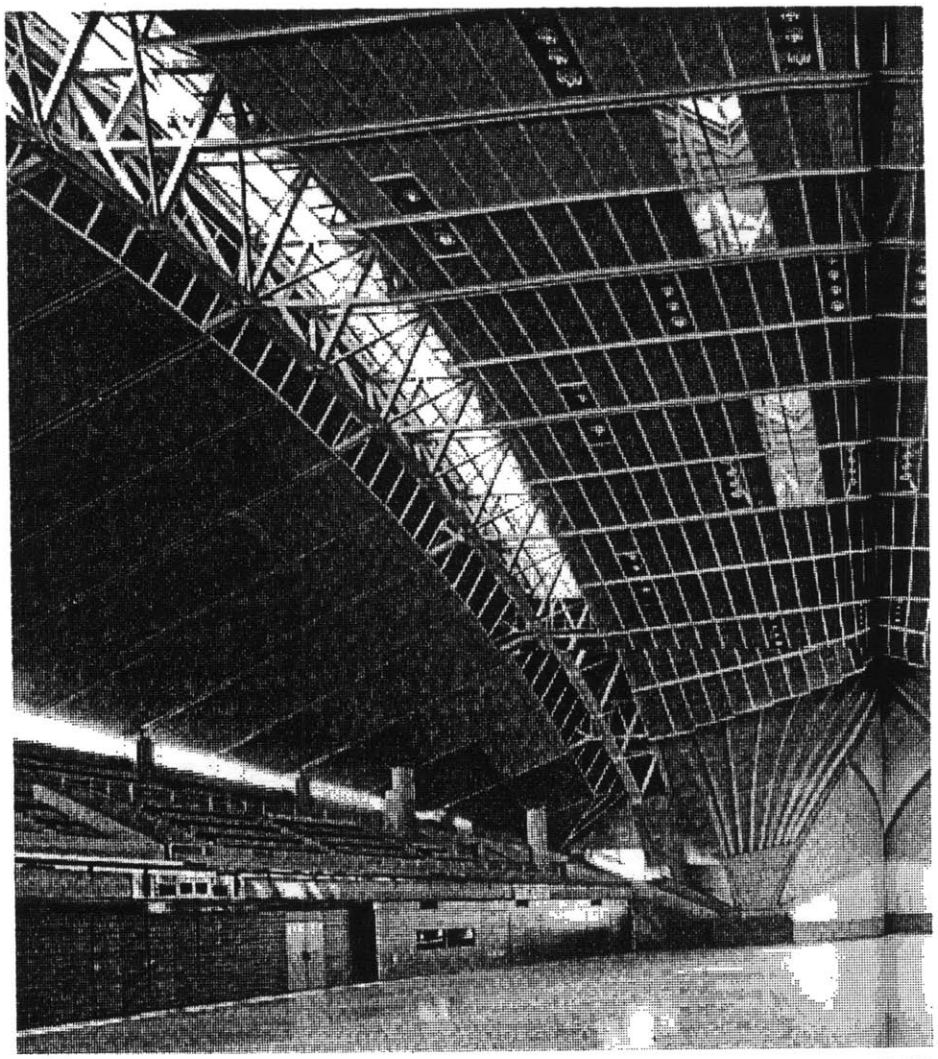

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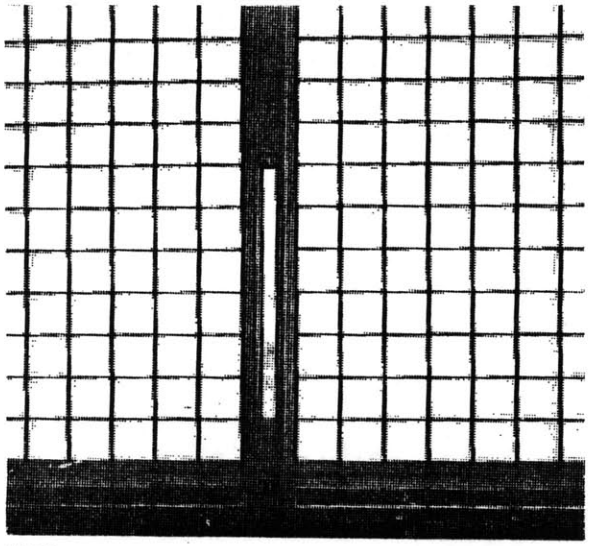

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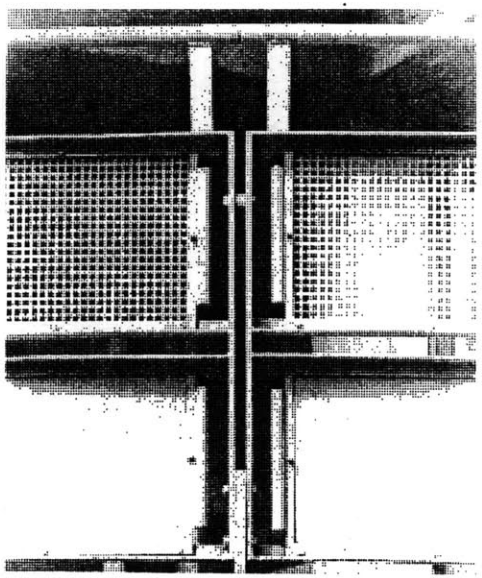

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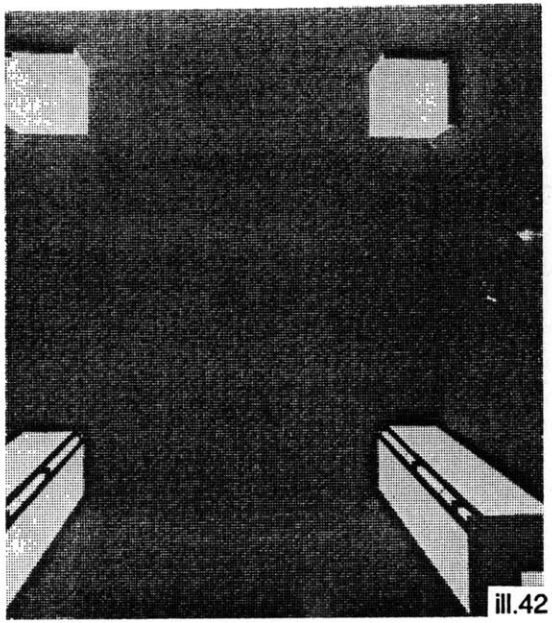

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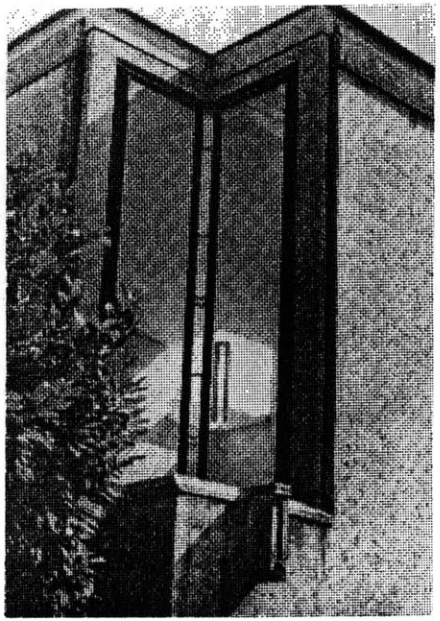

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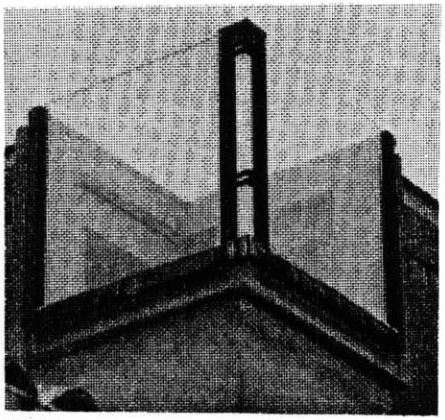

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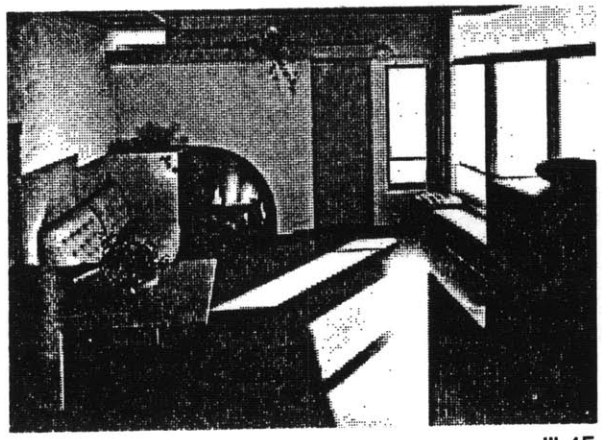

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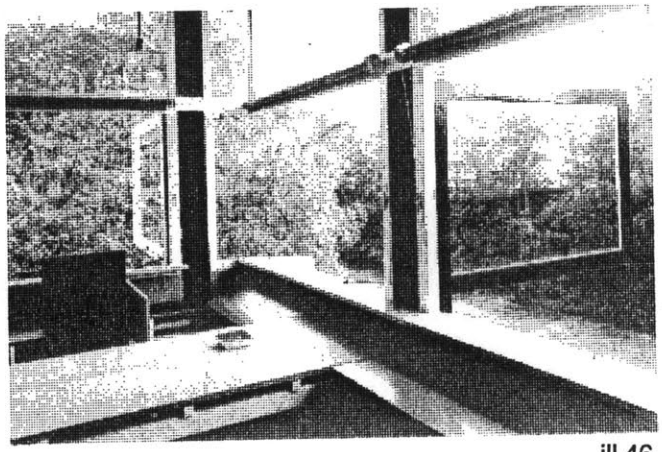

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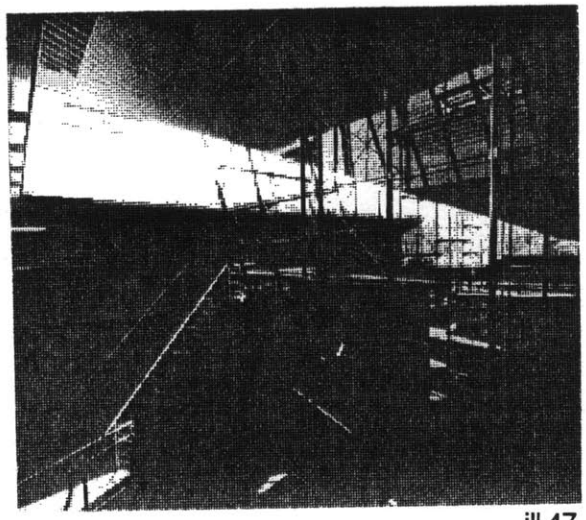
"The structural problem has been reduced to an equation. The approved stress diagram eliminates the need to emphasize the stability of the construction. Modern man pays no attention to structural members... He sees the daring of the cantilever, the freedom of the wide span, the space-forming surfaces of thin wall screens."

- R.M.Schindler
Modern Architecture: A Program



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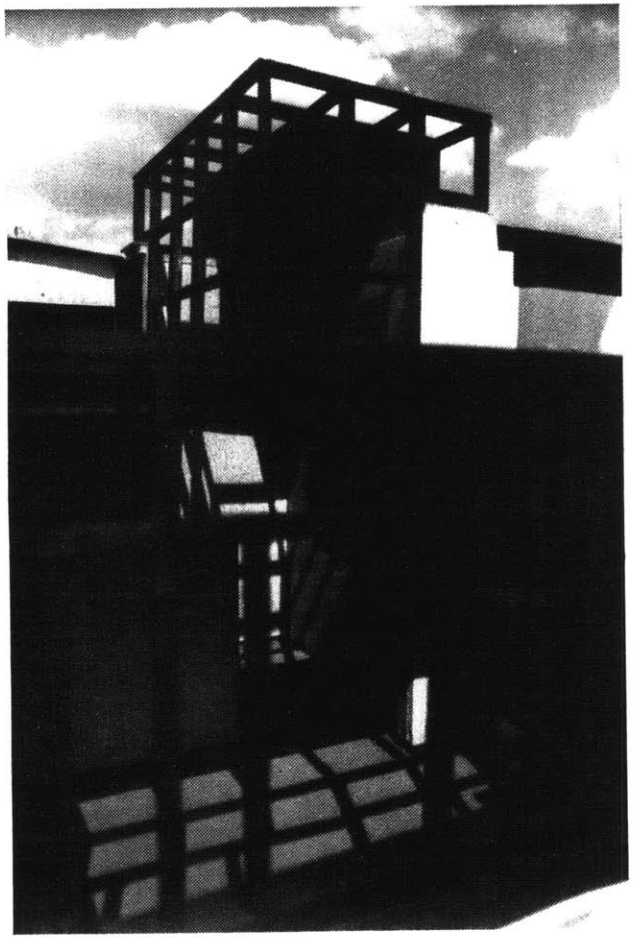
The "in-between " space

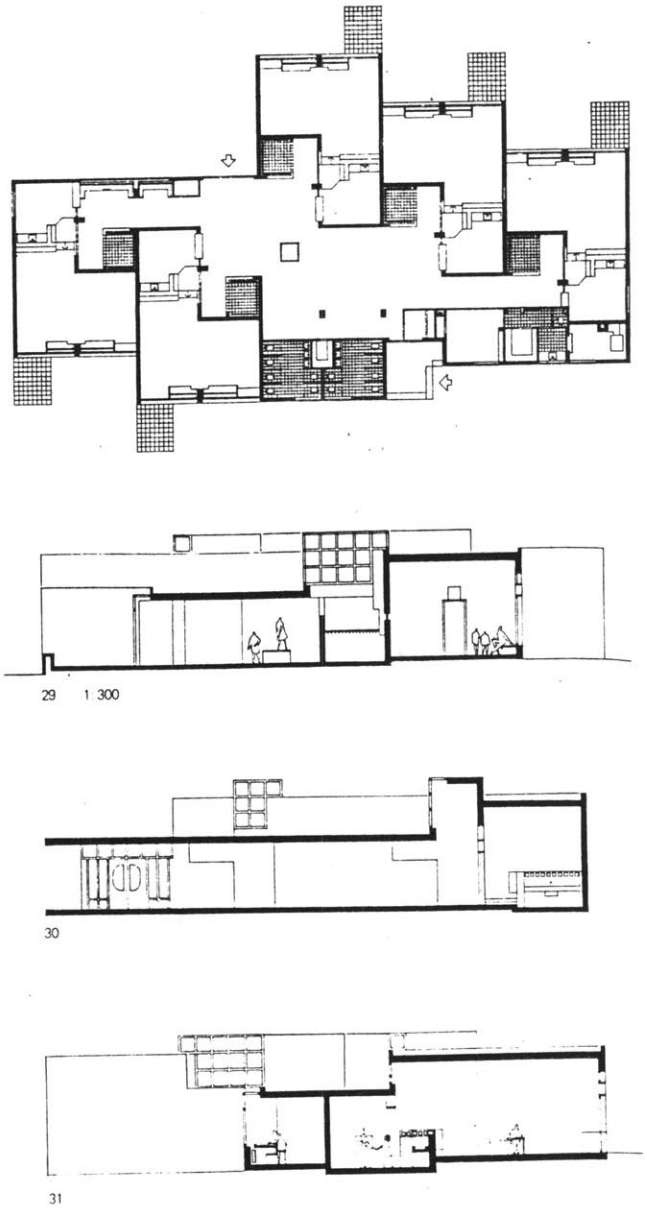
Model Reference:
Montessori School

Delft, The Netherlands Latitude 52° North
Herman Hertzberger
1966 Configuration

The design of this Montessori school was largely generated in response to the non-traditional teaching method that the montessori system uses. The method lets students determine their own curriculum, creating atypical teacher-to-student and student-to-student relationships. Therefore the classroom has to accommodate several activities at the same time. The typical classroom has been modified from the standard box shape to an L-shape that in conjunction with a floor level change starts to define a variety of activity spaces within the room. The classrooms are connected to a shared hall in a staggered configuration. A low walled coatroom encloses the stagger to define an in-between zone that sits both in the classroom and in the hall. It is here that Hertzberger uses a skylight to gather light and bring it into the space. These skylights serve to mark the classrooms and build the connection with the hall. By virtue of their relation to other windows in the

hall and their orientation to the sun, each has its own unique light quality. The arrangement of the skylights on the east and west sides of the hall allows the daily cycle of the sun to be experienced as it first intensifies the light on one side and then the other side of the hall.





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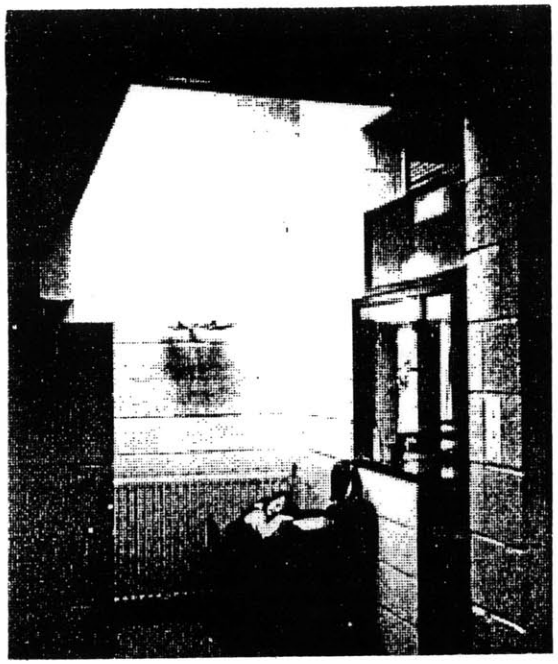

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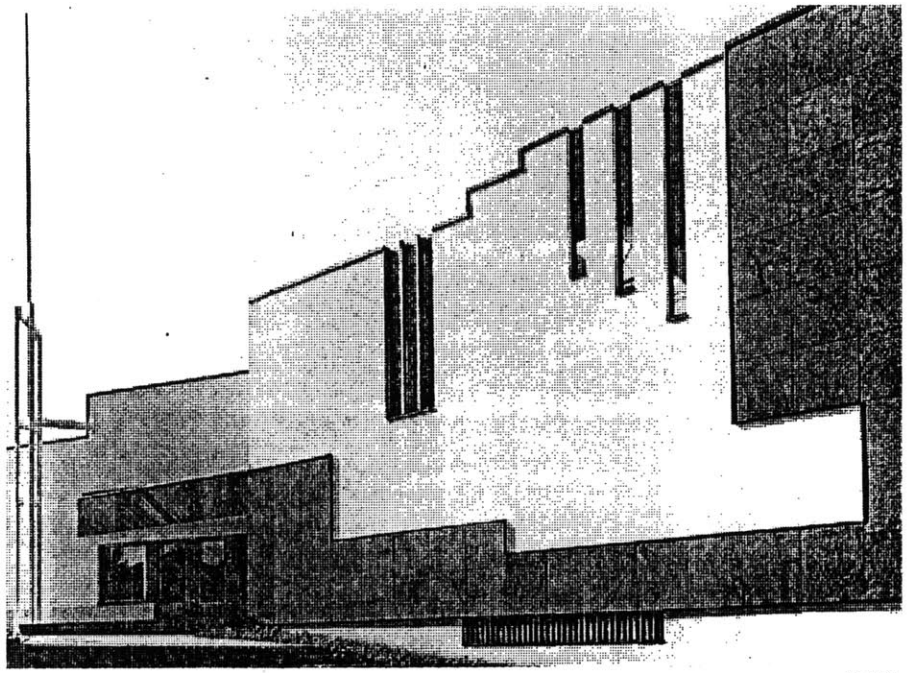

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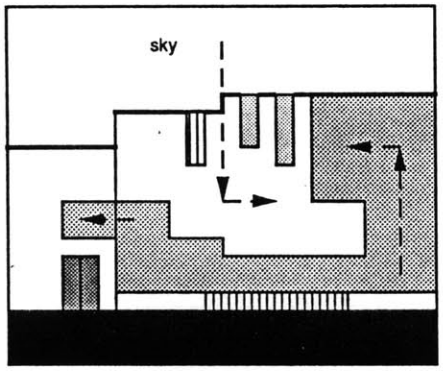


Light and dark materials on surface of the building represent the relationship between earth and sky. The building elevation becomes the transition zone that builds the exchange between the two.

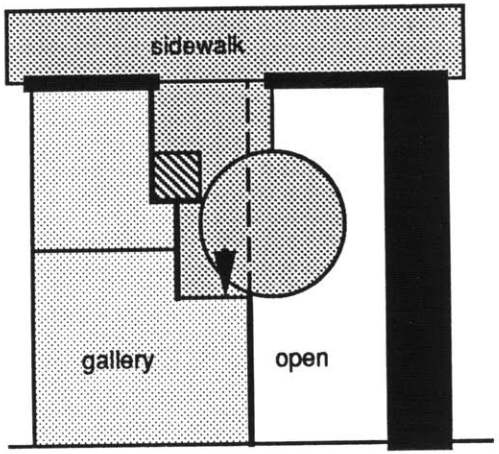
Light As A Connection

The phenomenon of light as a connection occurs when a zone that serves as a transition between two spaces is generated by light. This transition zone can be between an interior space and an exterior space, or between spaces within a building. Light as a connection is similar to light as a continuity because the role of this transition zone is to build an exchange, and therefore establish continuity, between spaces. Light as a connection is also similar to light as structure. Light becomes the moderating "material" that joins to things together just as light at the center of gravity unifies the material into a single section.

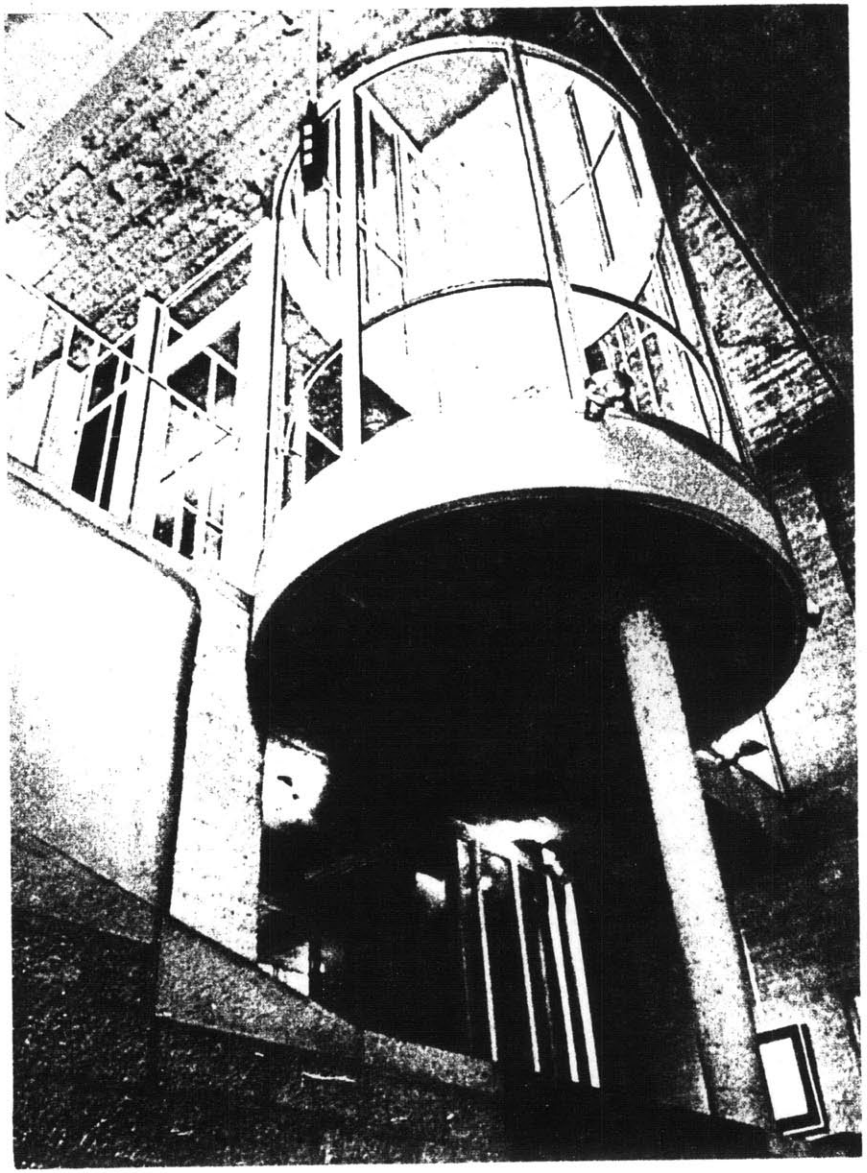
The following is a sampling of references that display this phenomenon of light as a connection.

"The exterior membranes of buildings and the street itself are the elements producing street space. But mere juxtaposition is insufficient for the creation of true street space; a morpological dialogue between the two is essential."

- Fumihiko Maki



The closure of the facade is pulled back inside to provide an entry space and a small circular containment This allows passers-by to actually comein and experience the gallery with out having to go inside. The circular piece continues up to the next floor so that light can pass from the upper gallery spaces all the way to gallery spaces that are below street level.



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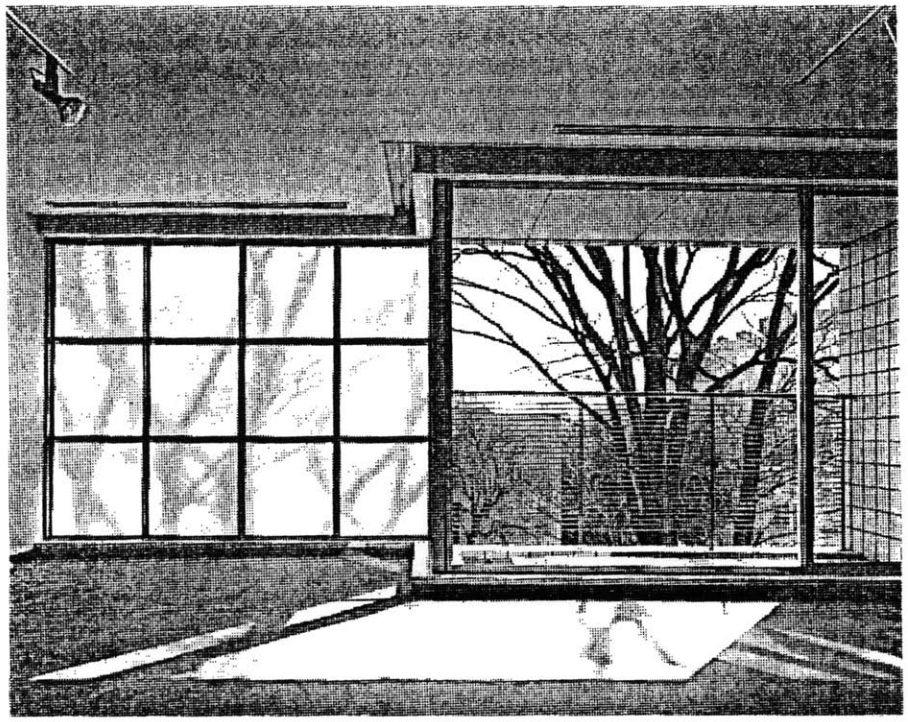

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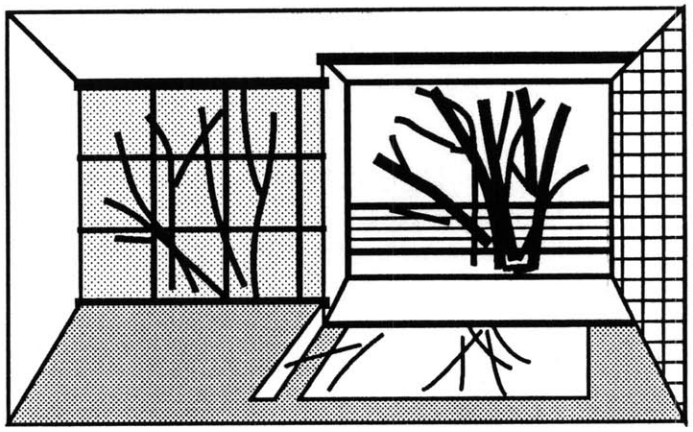
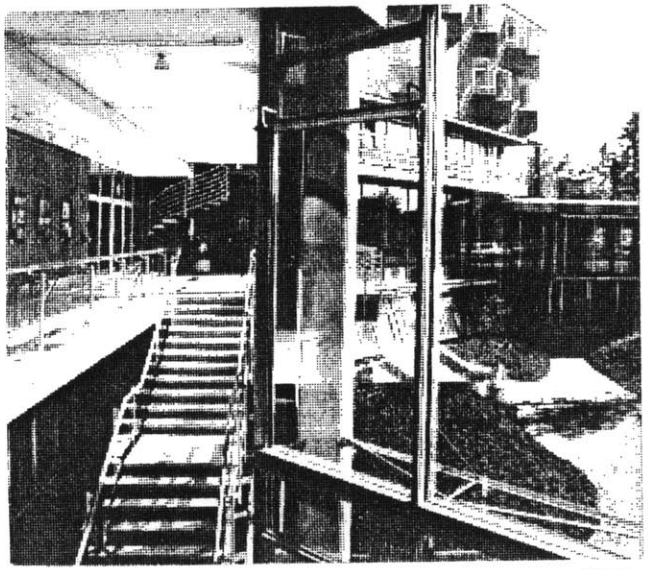


The balcony sets back from the facade allowing the outside to move within the enclosure of the apartment.The three views of the tree helps to build the connection between the inside and outside. The tree is seen directly trough the balcony opening; the silouette of the tree is seen on the shoji screen in the facade; and the shadow of the tree is cast onthe floor inside the apartment.



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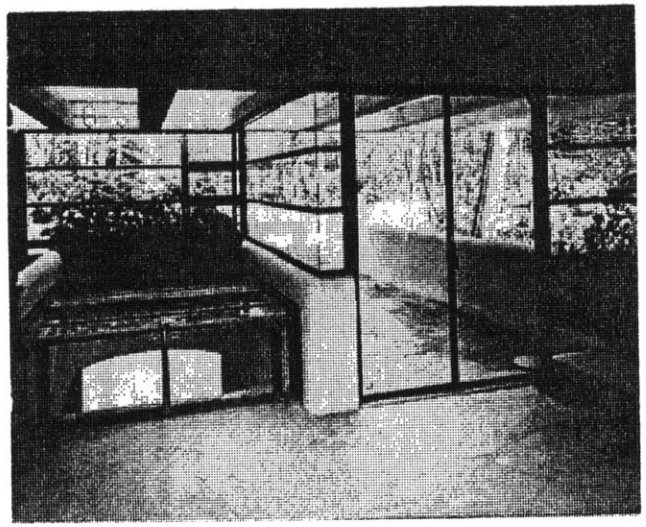

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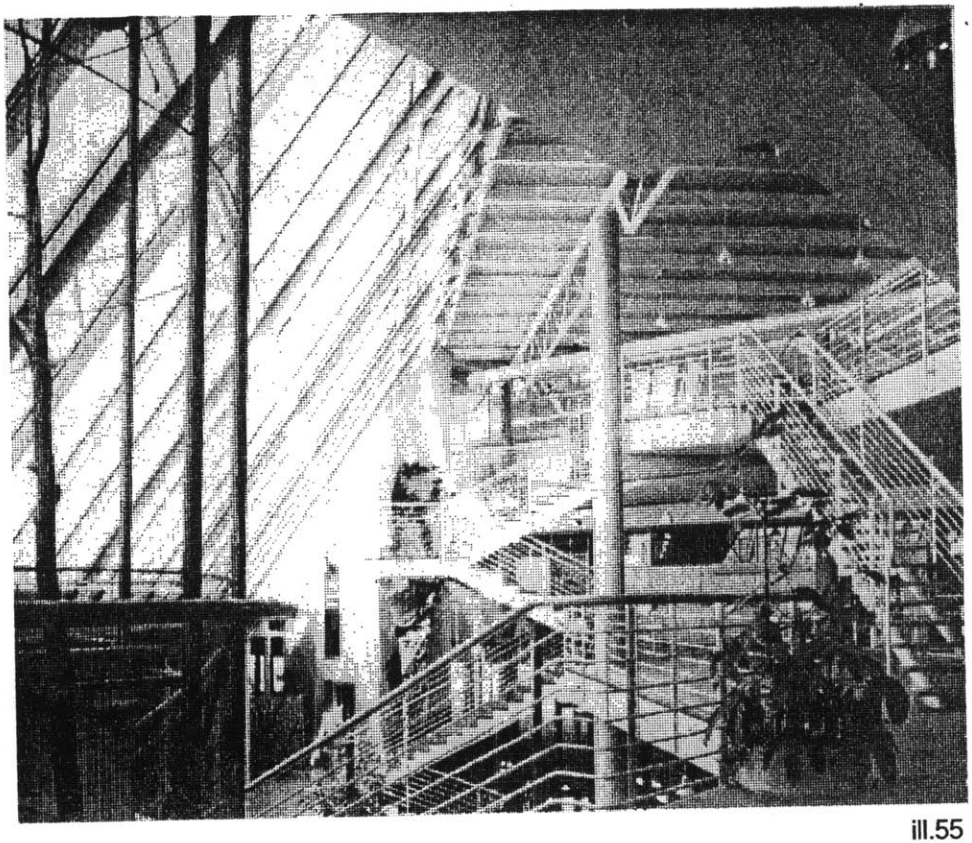

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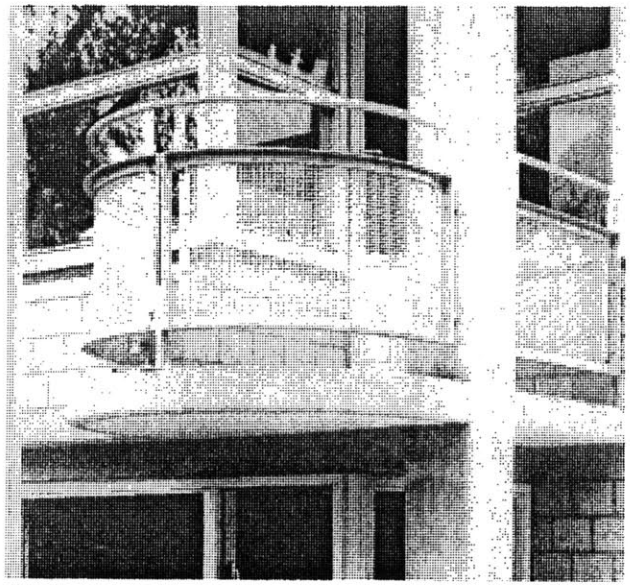

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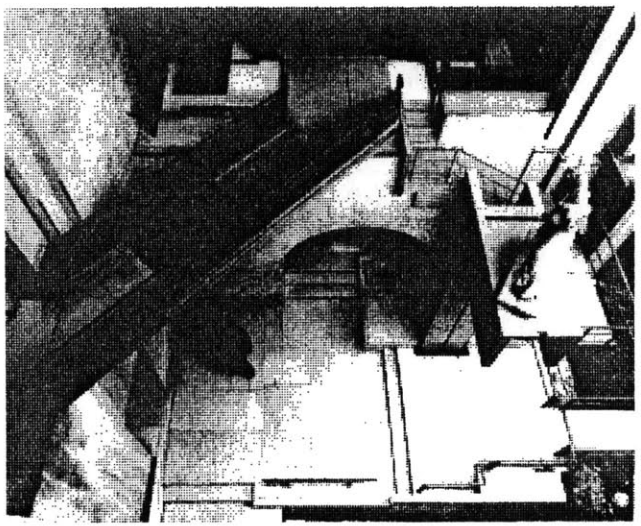

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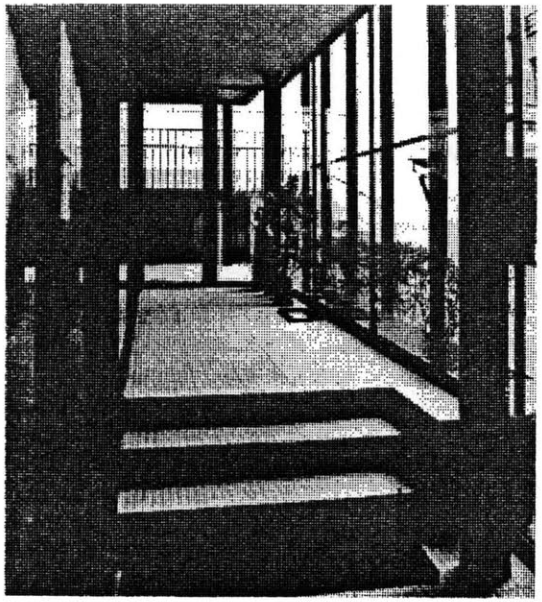

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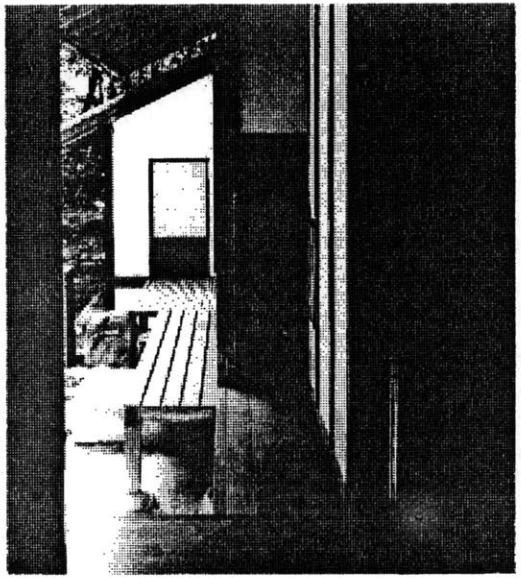

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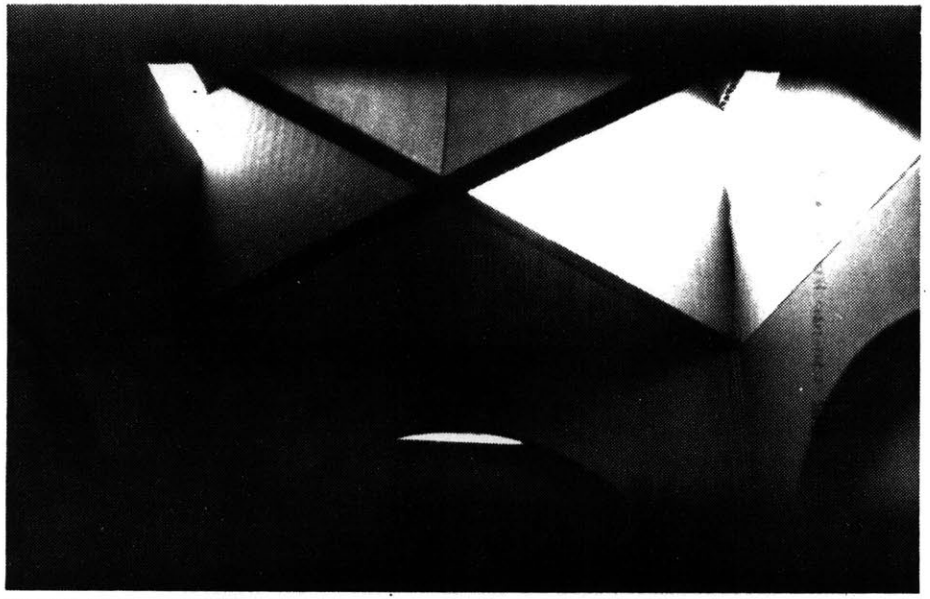
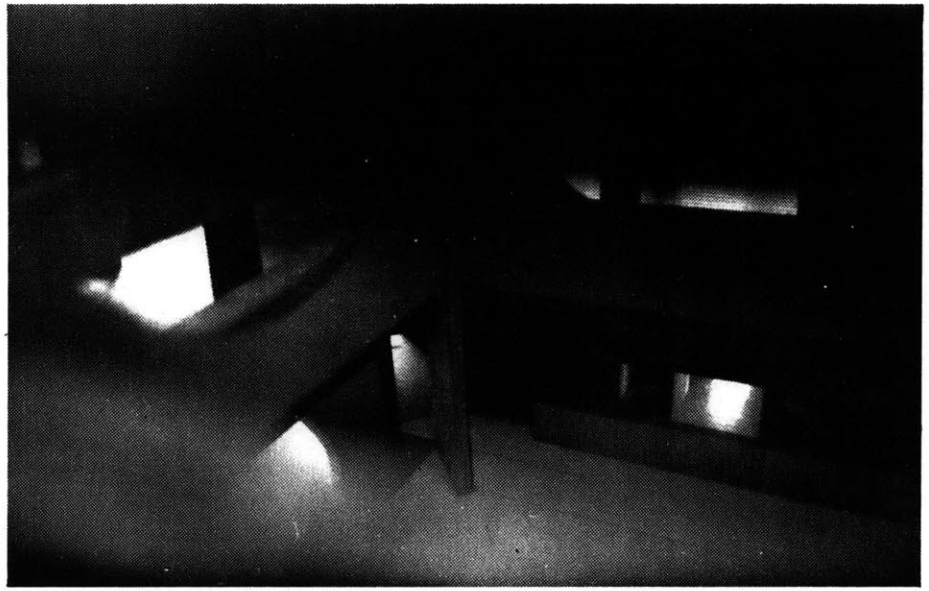


Floor of Central Space



Roof of Central Space

Model Reference:
Exeter Library

Exeter Academy

Exeter, New Hampshire Latitude 42° North

Louis I. Kahn, 1972

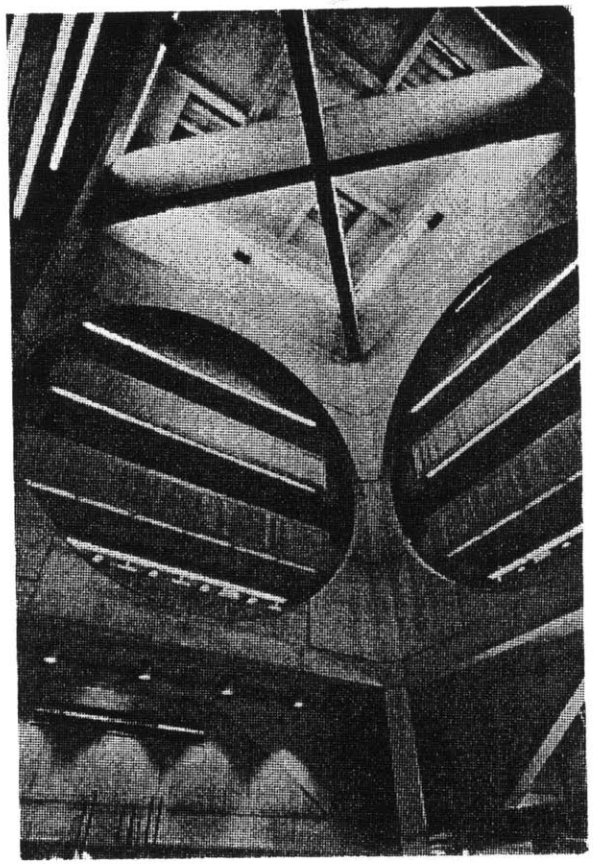
"I see the library as a place where the librarian can lay out the books, open especially to selected pages to seduce the reader. There should be a place with great tables on which the librarian can put the books, and the reader should be able to take the book and go to the light."

The above quote states the concept Louis Kahn had in his mind when he designed the Exeter Library. The building is organized around a large central space. The roof high above this space pops-up to allow light to enter through continuous clerestory windows. The light is then bounced down into the space by two large crossed beams that carry the roof. The roof does not sit directly on these beams, but is actually raised above the beams by small columns allowing light to pass in between. The light is also reflected off wooden panels that cover the balconies surrounding the central space. The wooden panels

subdue the light to a warm tone before it reaches the floor of the main space.

The building, as it surrounds this central space, is zoned as a light-dark-light sequence. The materials and structure reinforce these zones. The central space is one light zone. It is surrounded by a concrete shell with large circular openings which are infilled by the wood faced balconies that sit just behind the openings. The central space is wrapped with the zone for book stacks and mezzanines. The book zone is defined by exposed concrete beams, piers and low ceilings which in conjunction with the book stacks function as a screen that diminishes the amount of light in this zone. The perimeter zone of the building is made up of double height spaces filled with light from the large exterior windows. The structure of the perimeter zone is a three-dimension frame of high brick arches. Here again, wood is used to cover the mezzanines which face onto these spaces, and to cover the bottom half of the windows at the study carrels.

The structure, materials and the books themselves generate a three-dimensional framework that screens the light as it moves through the space.



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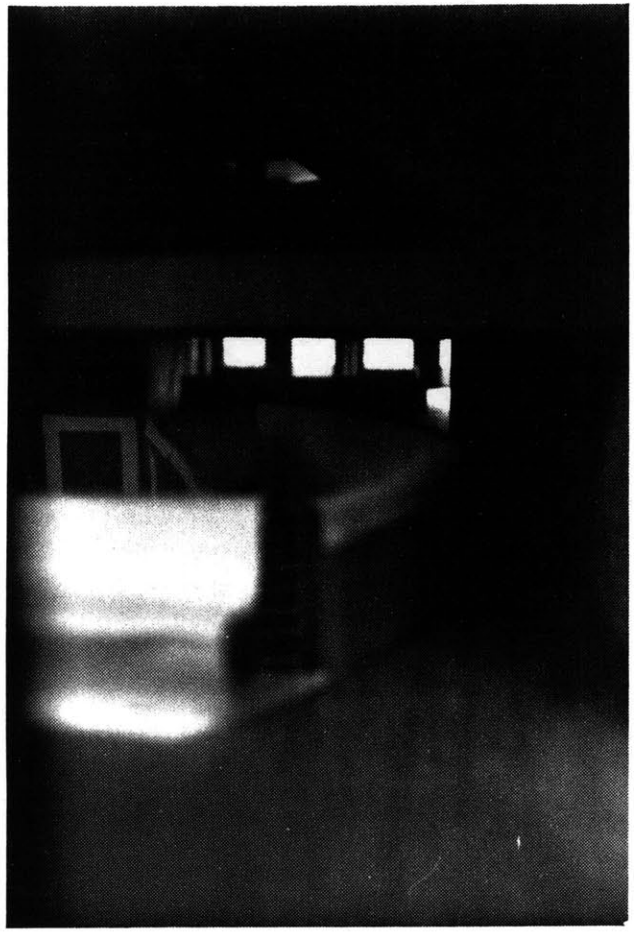
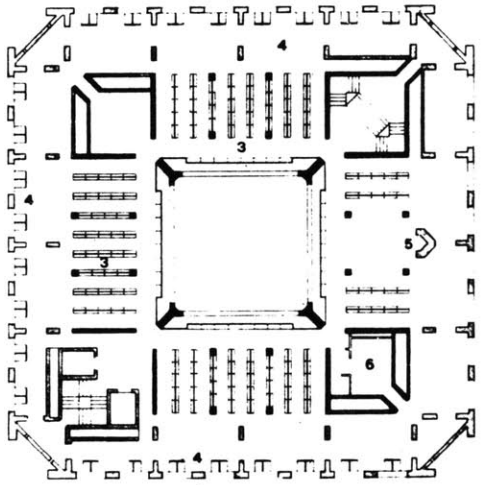
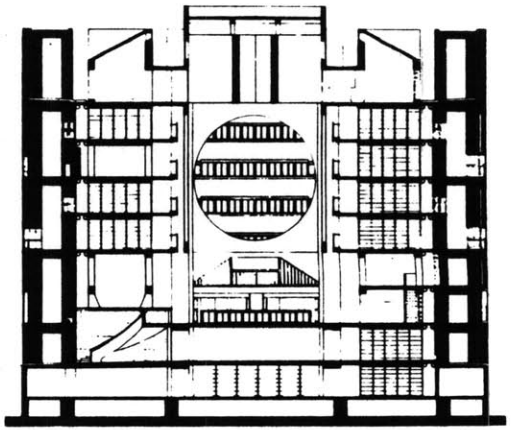
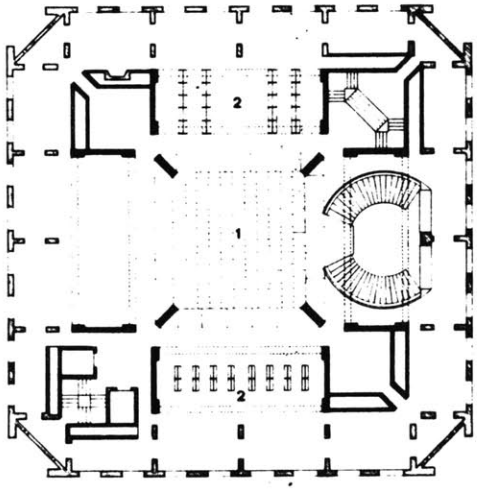




Third-floor plan

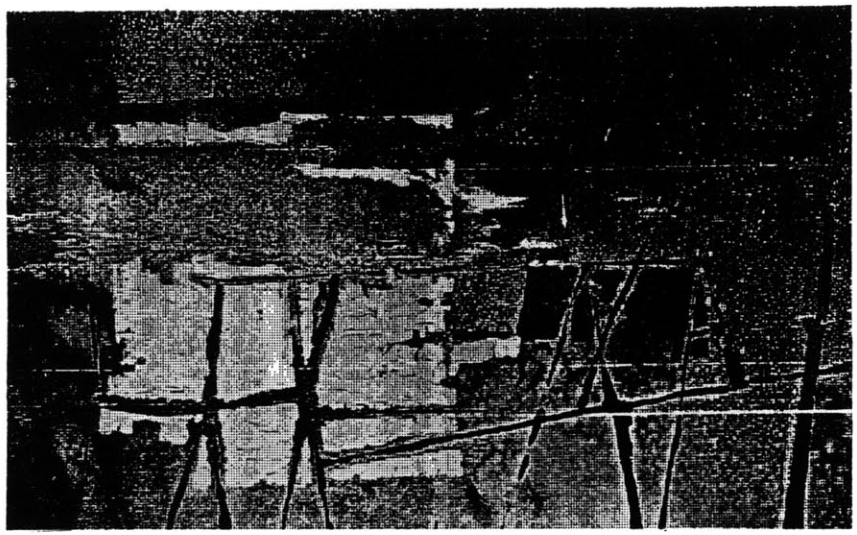


Section



Entrance floor plan

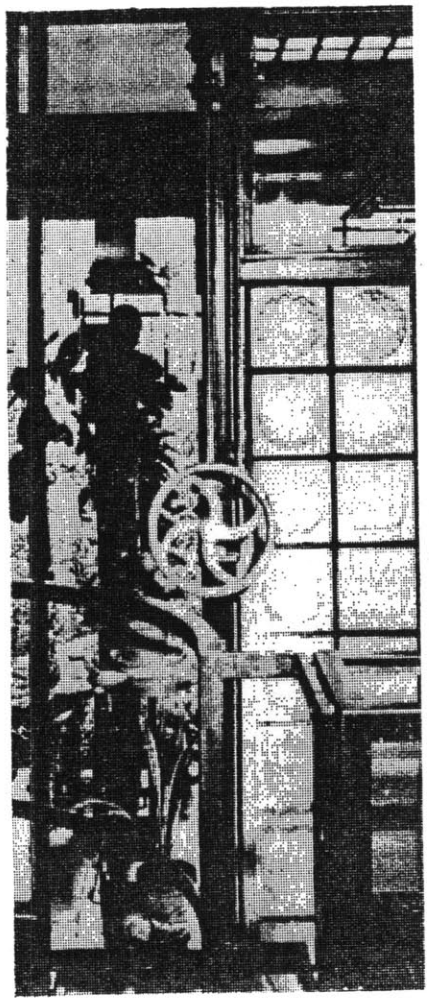
ill.61



ill.62

The Relation of Light and Screens

Screens are physical things, not phenomenon. They are made up of a variety of materials such as: metal, wood, plastic, translucent, clear or colored glass, plants, books, hanging pots, etc. They occur in a variety of densities. In fact the range of densities is such that it is ambiguous as to when a screen becomes so dense that it is a virtual wall. A single pane of clear glass can not be considered a screen because although it transforms light, it does so in a way that is almost unnoticable. The whole purpose of a screen in terms of light phenomena is to make us aware of the presence of light. Screens are able to do this while still providing some spatial definition. This is the value looked for in this exploration. The following is a sampling of references that demonstrate the capabilities of screens to interact with light.



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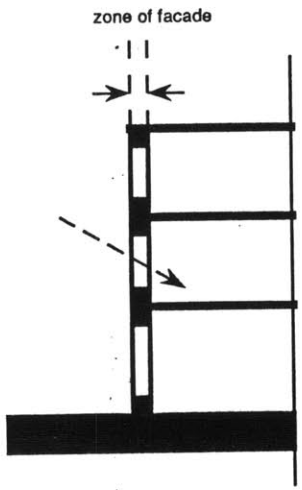
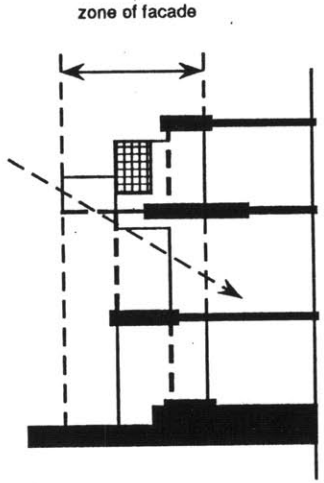
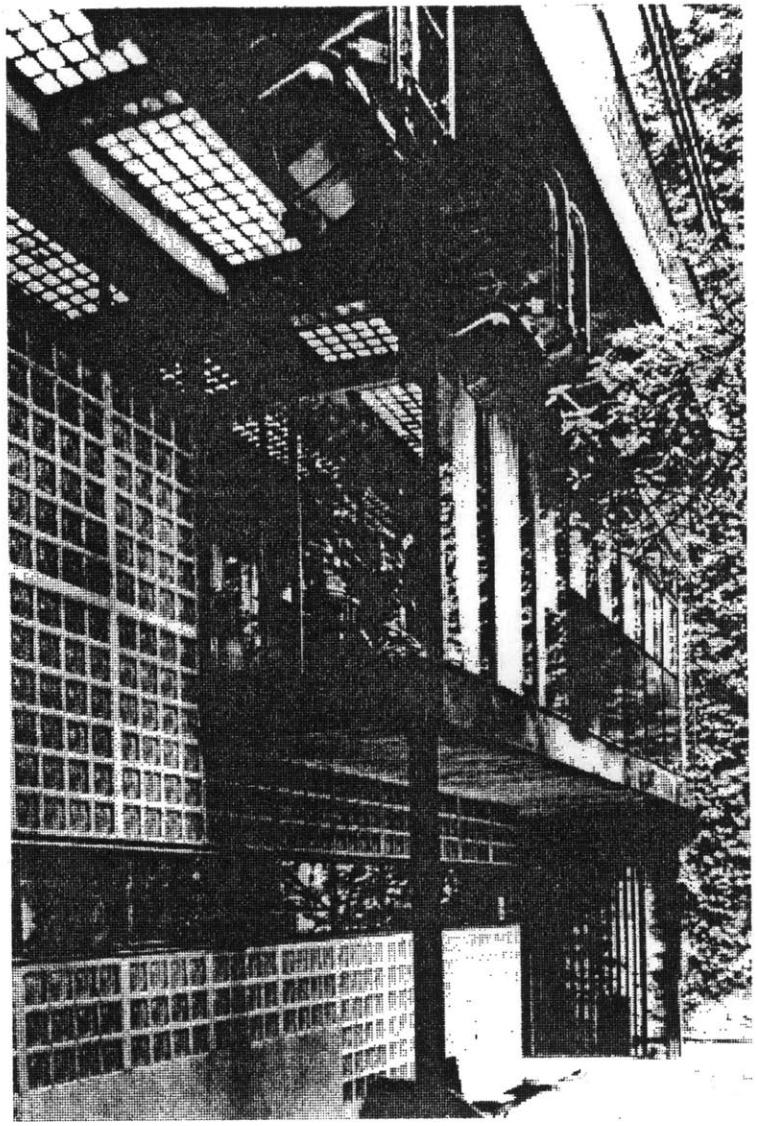


1:1 relationship between the interior and the exterior. Light only passes from one zone to the other.



Larger zone of facade builds an exchange between interior and exterior. Light connects several zones together.



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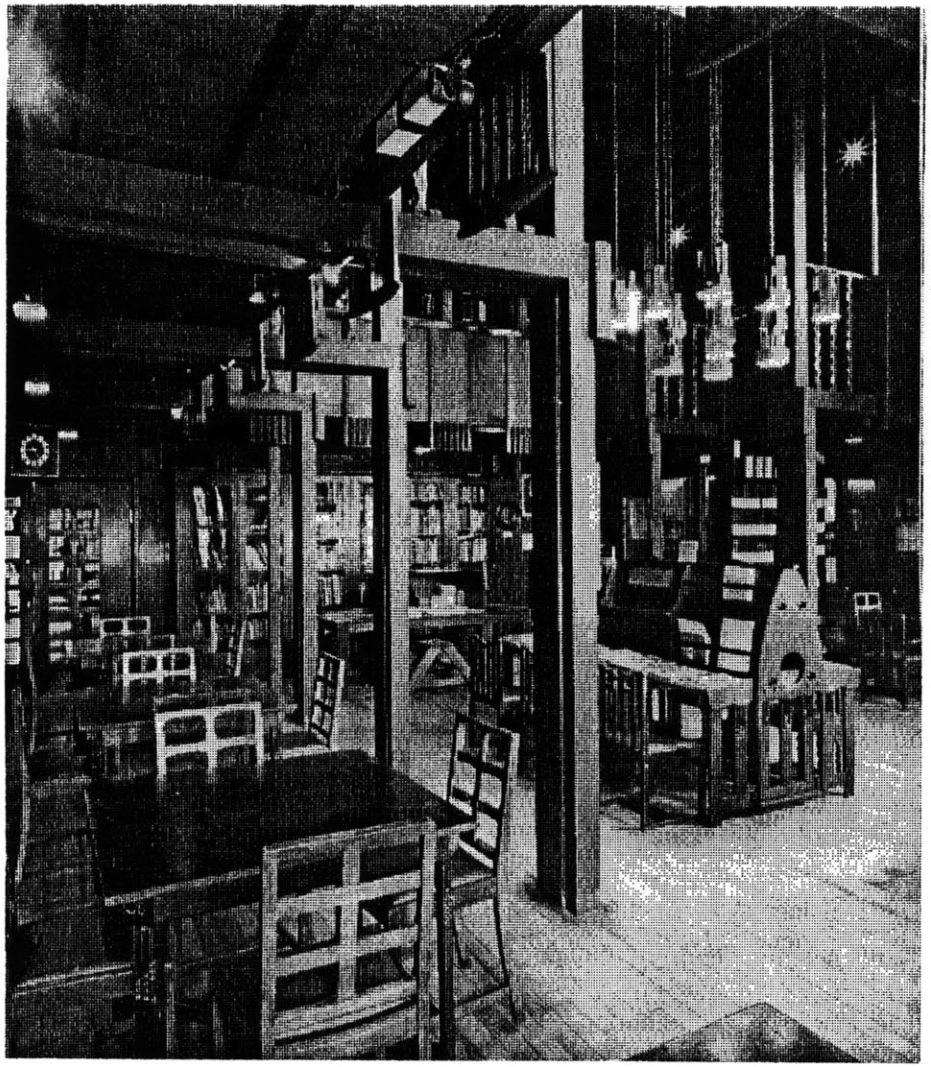

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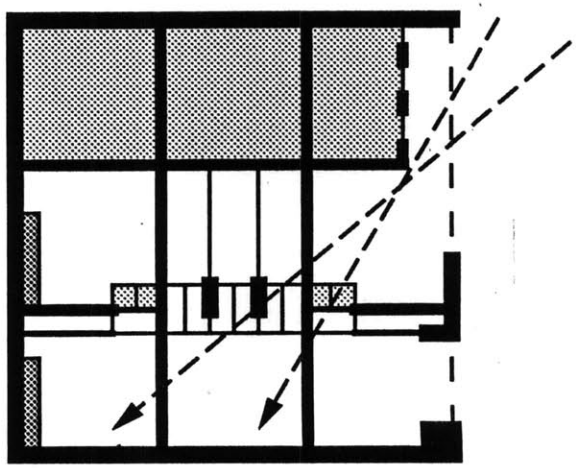

The wooden structure of posts and double joists set up a 3-D framework at the larger room size. Mezz. floors are held back from the posts to allow light through. The light fixtures , furniture and railings intensify the light at various zones within the space. The assemblage of the large windows from small panes of glass also acts to screen the light as it enters the space.

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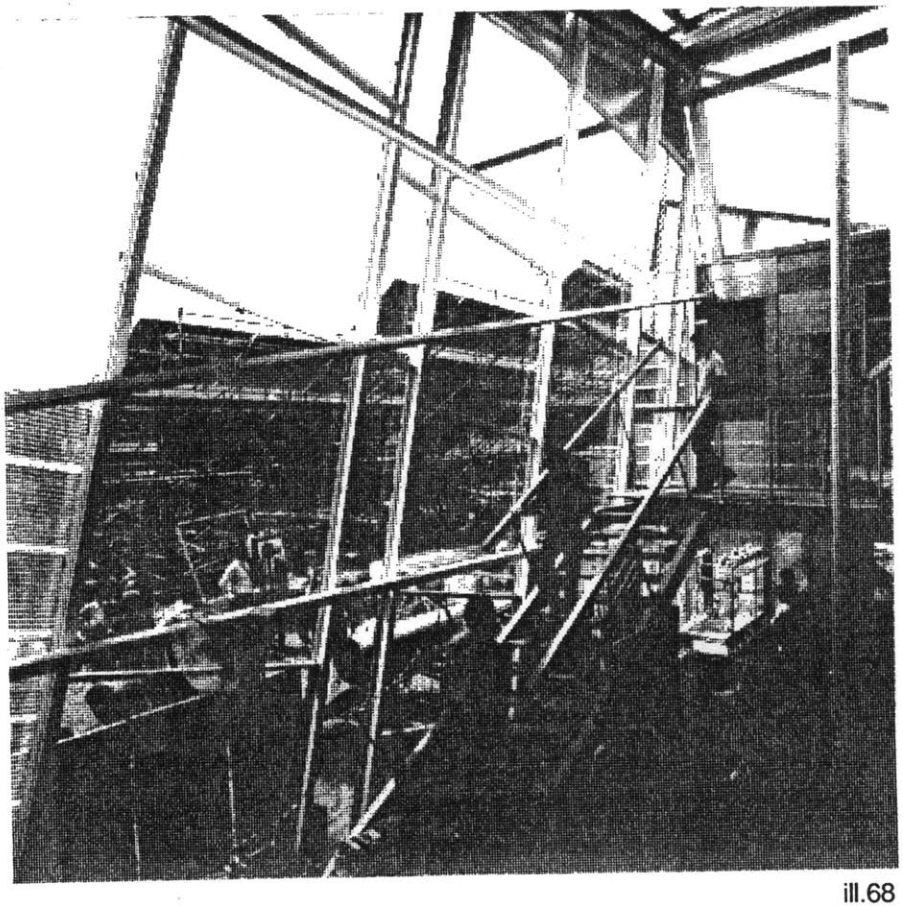

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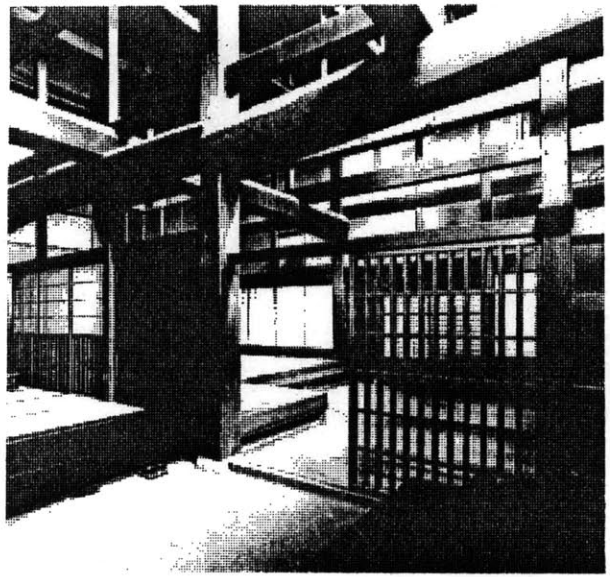

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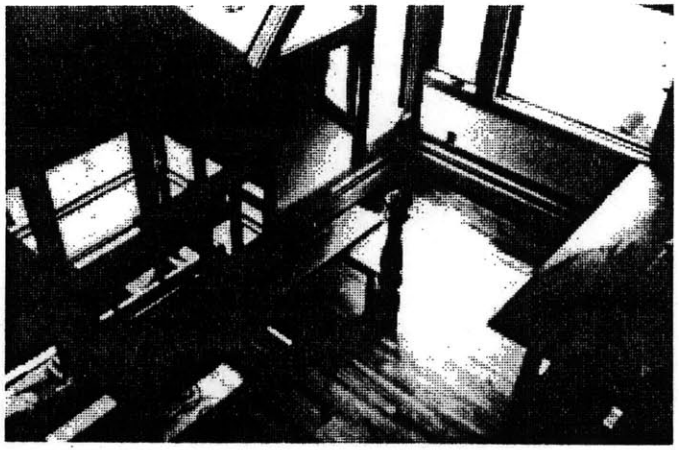
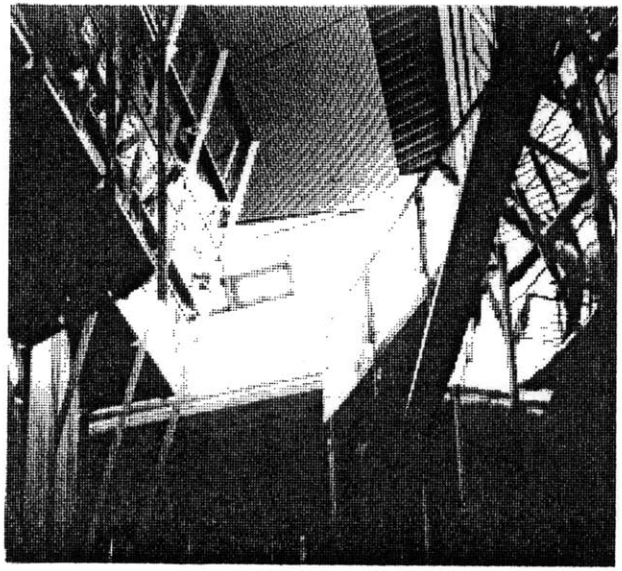
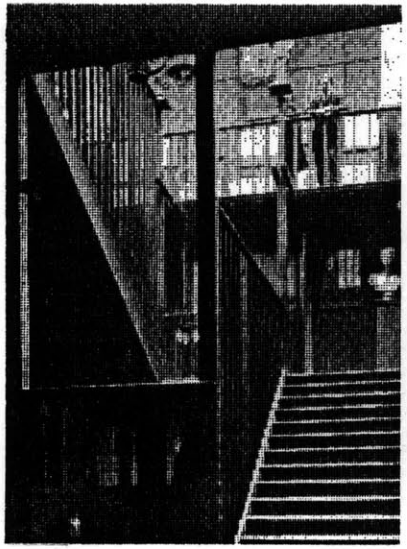


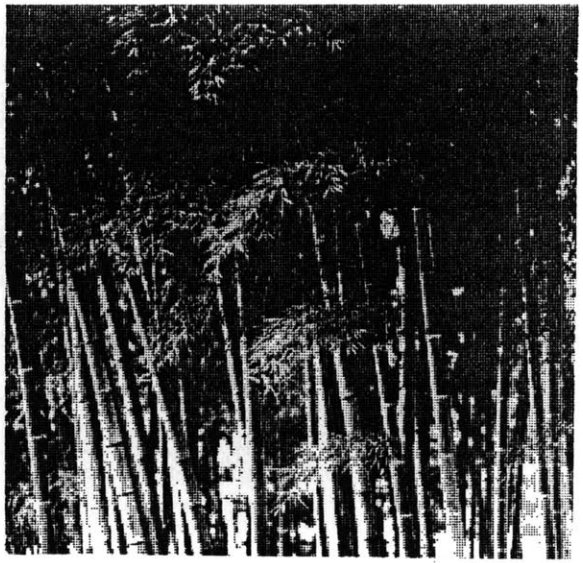
ill.70



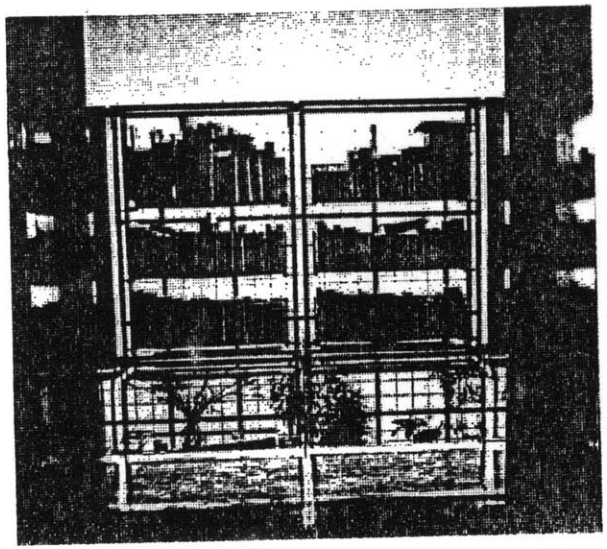
ill.71



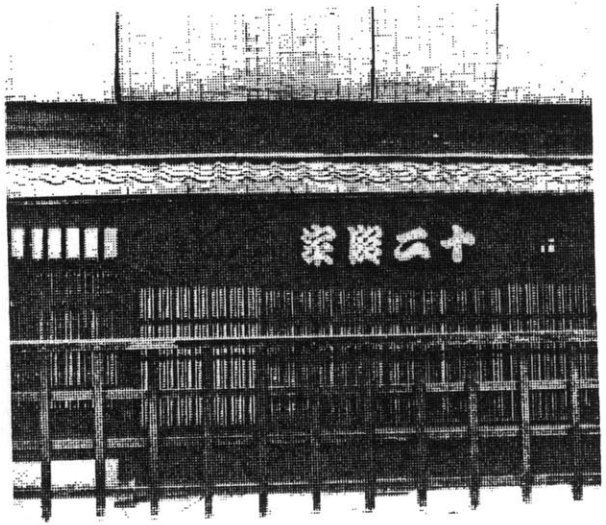
ill.72



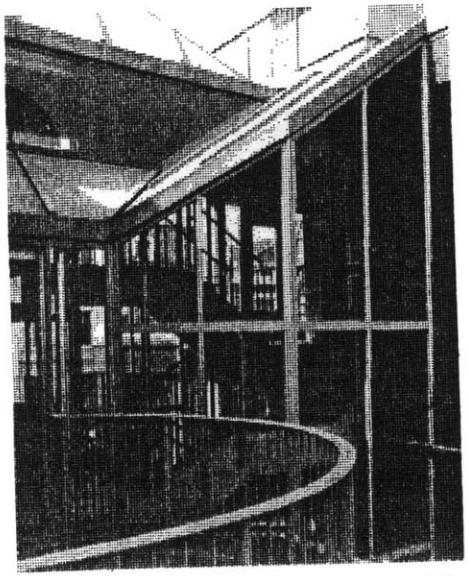
ill.73



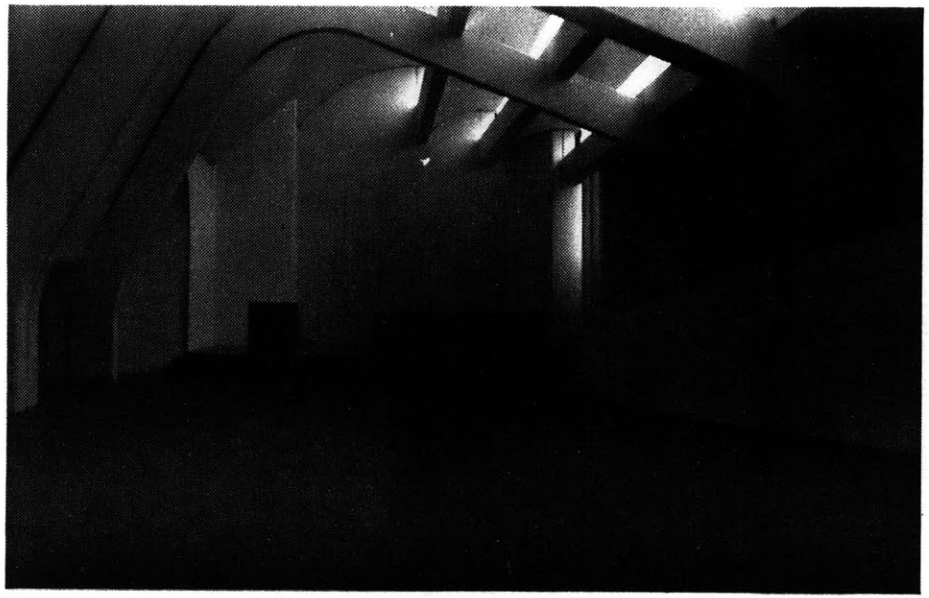
ill.74



ill.75



ill.76



Nave of the Church looking towards the Altar

Side Chapel from the Entry

Model Reference:
Santa Maria di Assunta

Parochial Church

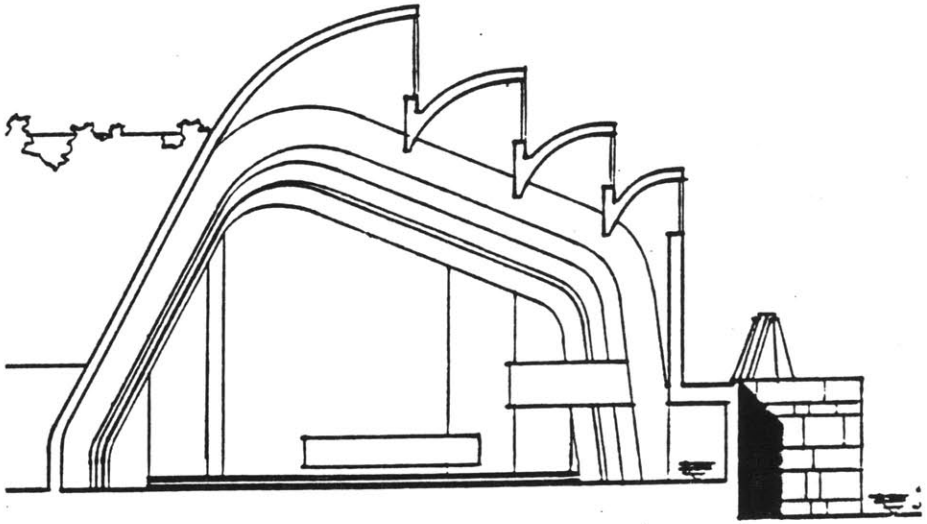
Riola, Italy Latitude 44° North

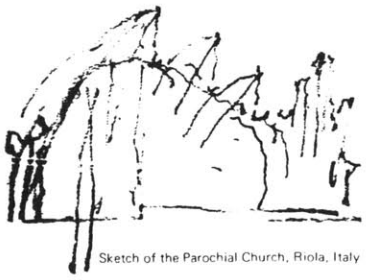
Alvar Aalto, 1975 to 1978

In Santa Maria di Assunta, Aalto uses perceptively simple means to moderate and transform the light, enhancing the experience of the space. The plan is a fan shape that narrows near the altar. This tapering from east to west is reinforced in section by a series of rounded concrete arches that repeat in gradually smaller sizes, also towards the altar. The main light in the space is brought in through a series of north-facing curved monitors that also run in the major direction. These monitors spring from the tops of the arches allowing light to filter down through the structure. There are a series of openings in the north elevation that start as high clearstory windows in the large west end; disappear in the middle of the elevation and then reappear as tall thin glazed openings between a series of fins. This establishes a ligh-dark alternation from the seating to the altar. The materials on the walls and the ceilings are plastered concrete painted flat white. This in combination with the rounded edges, curved roof

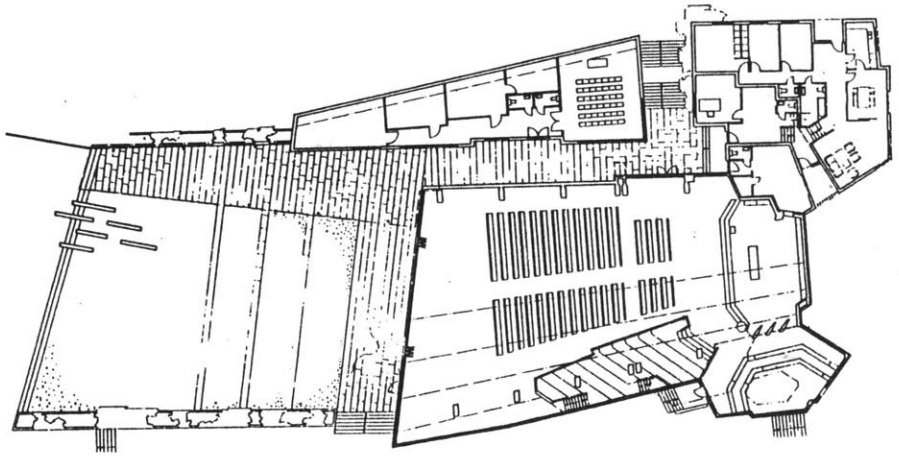
and wall shapes and the diffuse north light eliminates any sharp shadows making the space seem very calm and serene. The light, by virtue of the narrowing in plan and section, and the relative increase in openings, is intensified around the alter.

There is a small chapel space adjoining the church on the north side of the alter directly opposite the main entry. This chapel is lighted by a large skylight which is located so that it receives direct sunlight. This provides a bright warm glow, in sharp contrast to the cool diffuse light in the rest of the church, which generates the containment of the chapel.





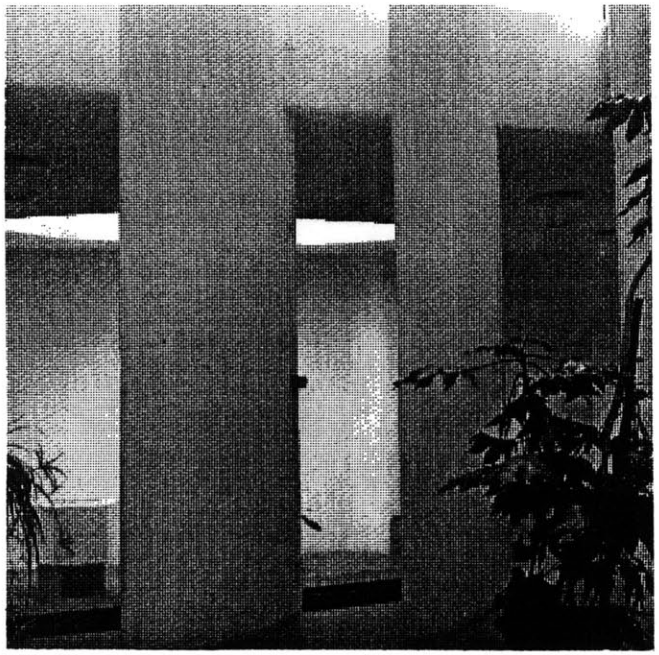
Sketch of the Parochial Church, Riola, Italy



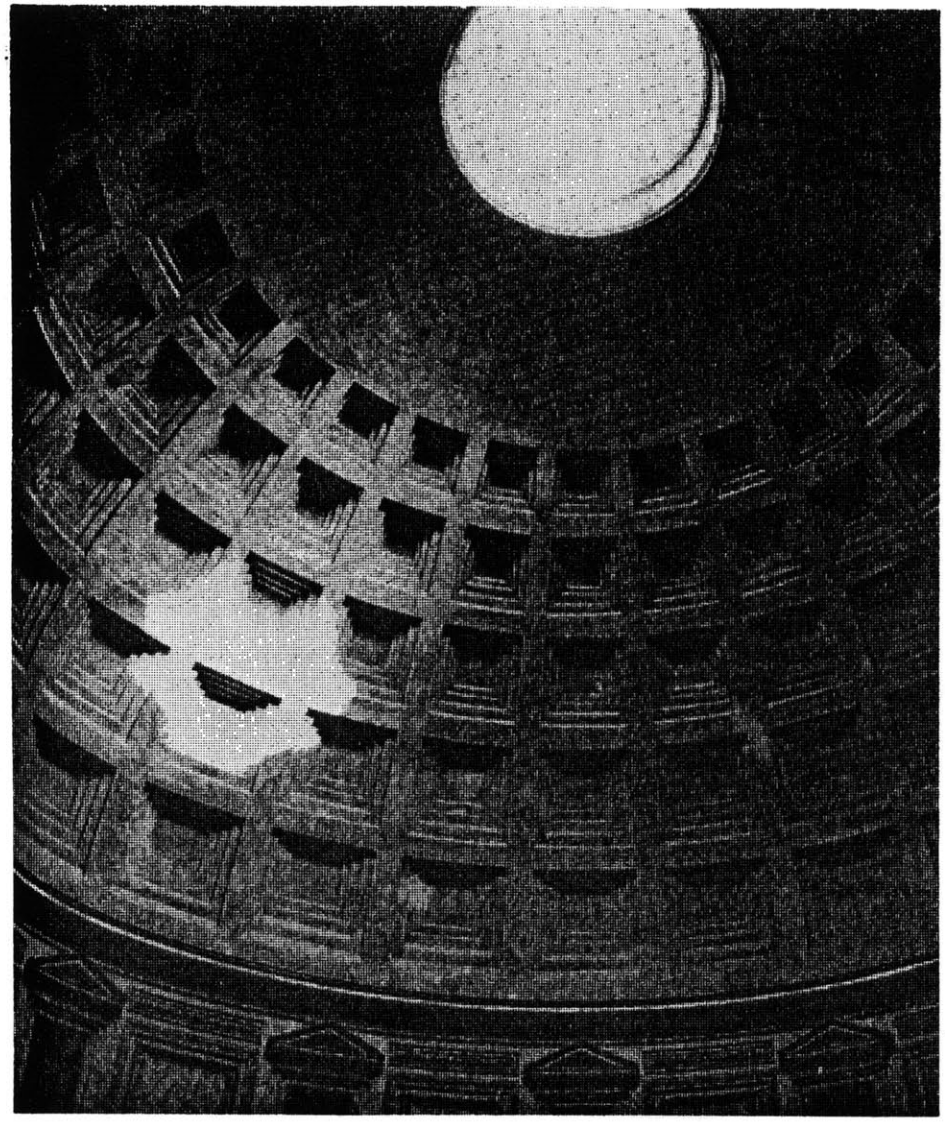
平面図. Plan.

ill.77

84



ill.78

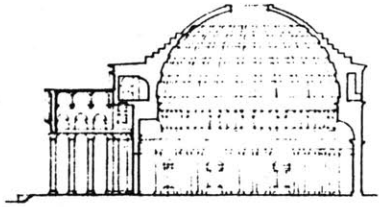


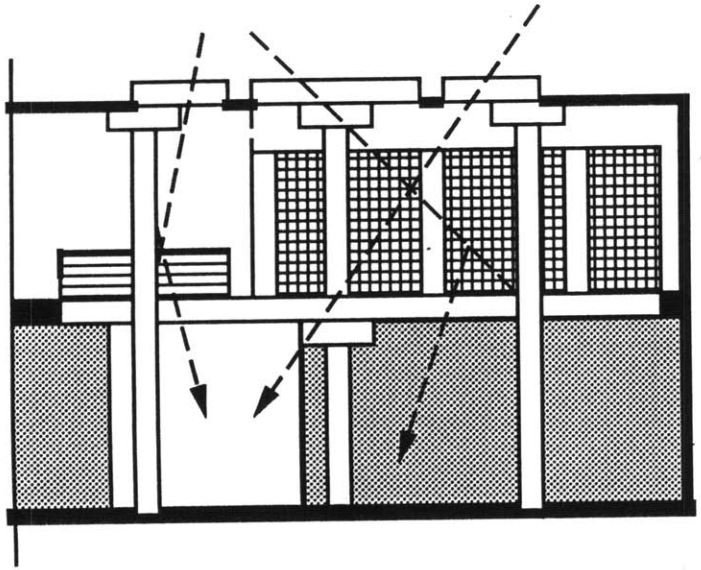
ill.79

Light As A Containment

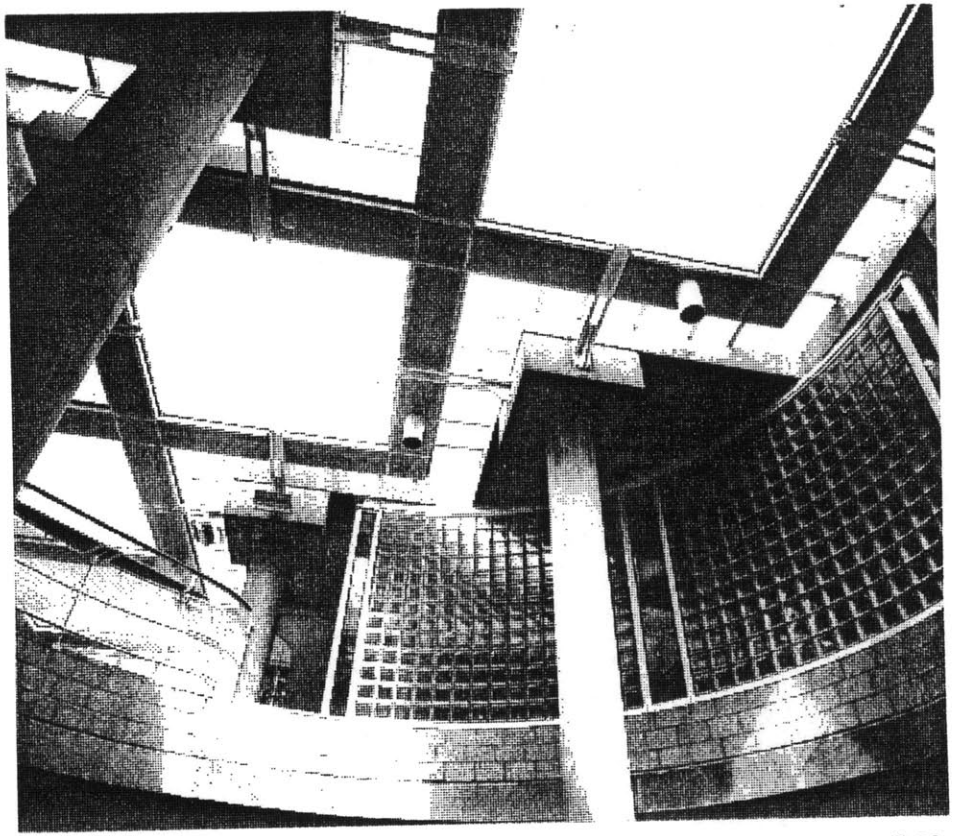
This phenomenon is a partial reversal of light as a continuity. Instead of light being allowed to continue through several spaces, light in this case is being contained, filling up and defining the space. Often, surfaces and materials are used to intensify the light and to spread it around the space. Since light here is generating a stopping place the form of the space tends to be regular in shape. Also, the typical light volume is often most easily achieved when the majority of light comes from above and is diffuse. Although most examples of this phenomenon occur at a collective size, it is not unusual to find it working at other sizes, too.

The following is a sampling of references that display this phenomenon of light as a containment.

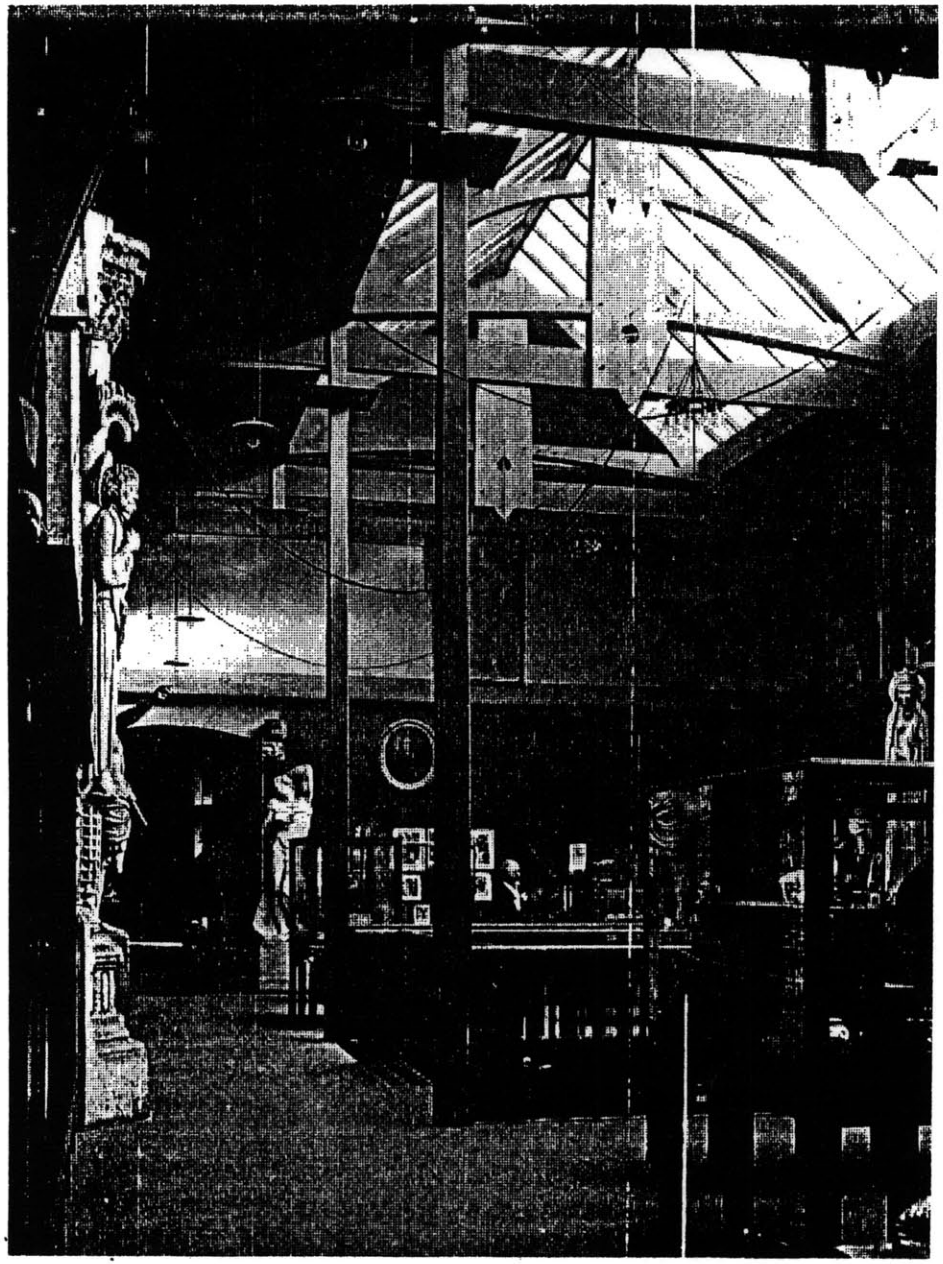




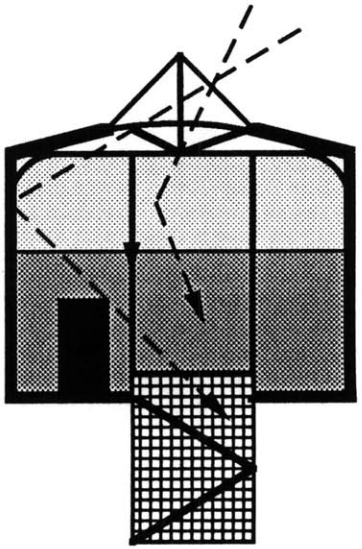
Light is contained in the space by a variety of materials and by the cicular form. The "dark" conc floor and walls establish the definition of the containment. Lighter, more transparent materials such as the railings and the glassblock allow light to make a connection between this space and the spaces around it. The columns carry the light down serving to connect the upper and lower levels.



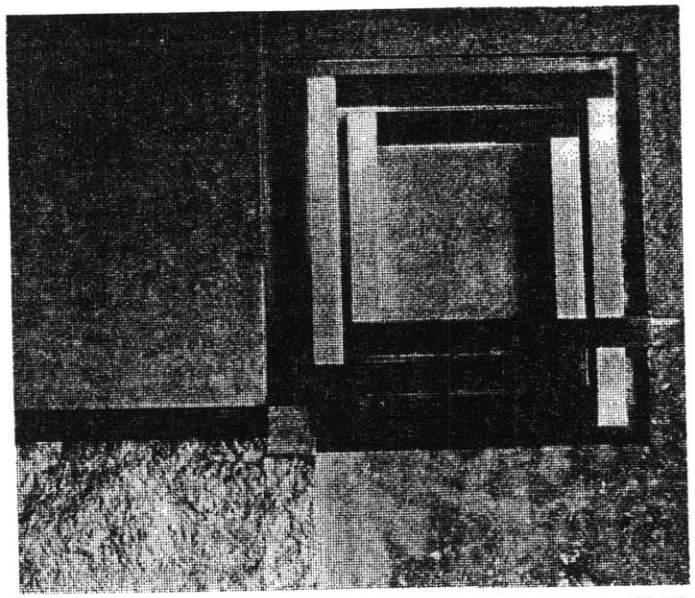
ill.80



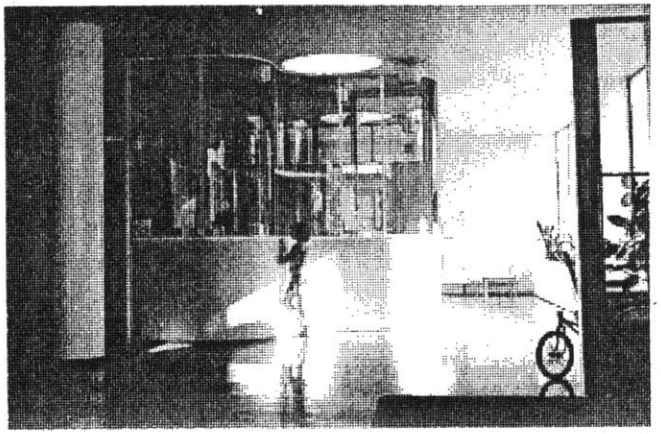
ill.81



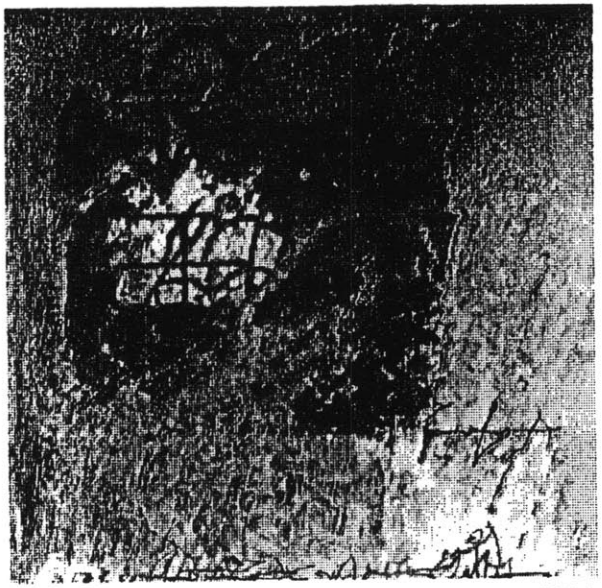
This space is horizontally layered in terms of light. The top zone is the skylight. The roof trusses inhabit this zone and act as a screen. The wall surfaces of the second zone are light colored plaster which reflects the light down into thelowest zone where art is displayed. This lower zone is panelled with a dark wood that absorbs most of the light there by preventing glare that would make viewing the art difficult. This dark zone helps to contain the space. Light is also allowed down the stair case by way of a continuous railing to other floors below.



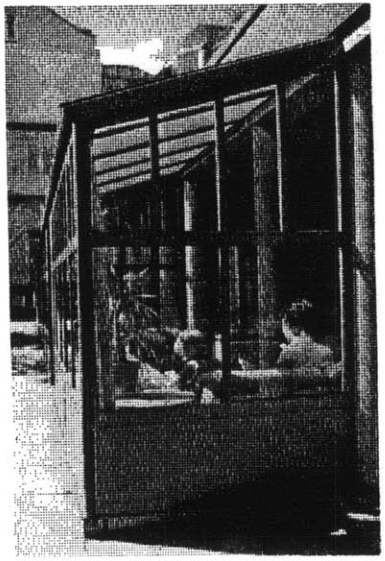
ill.82



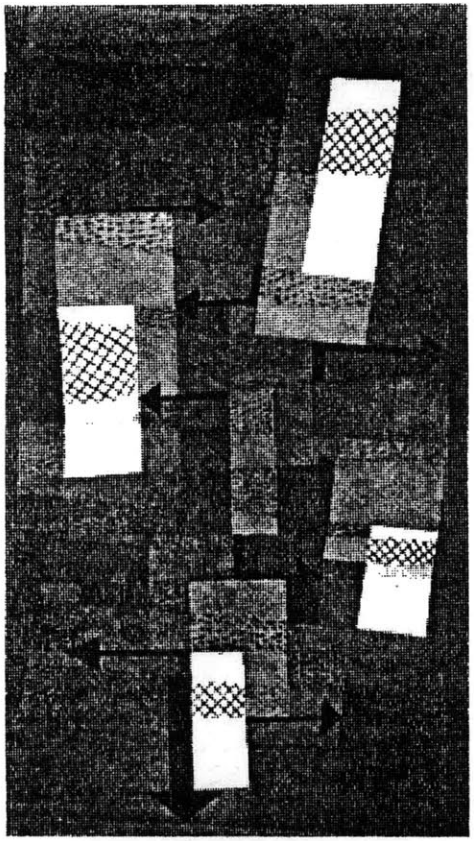
ill.83



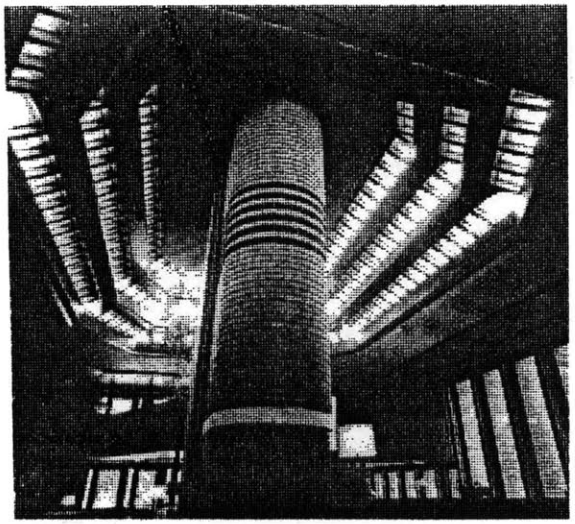
ill.84



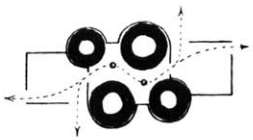
ill.85

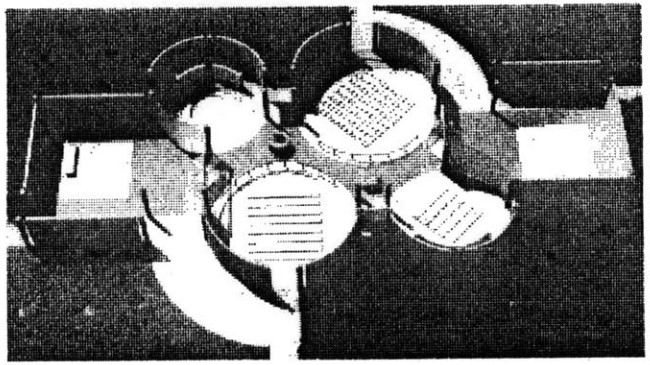


ill.86

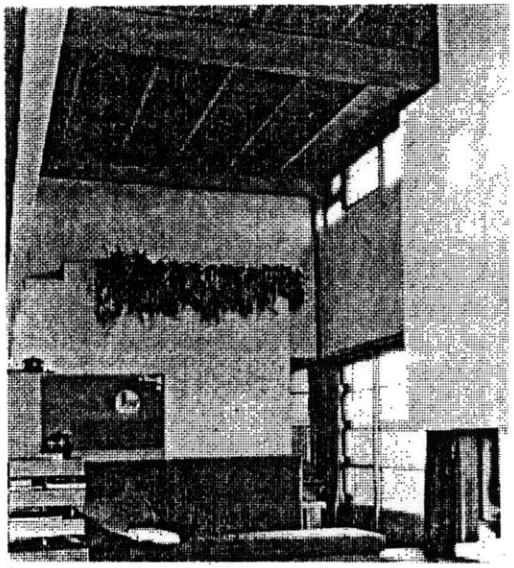


ill.87



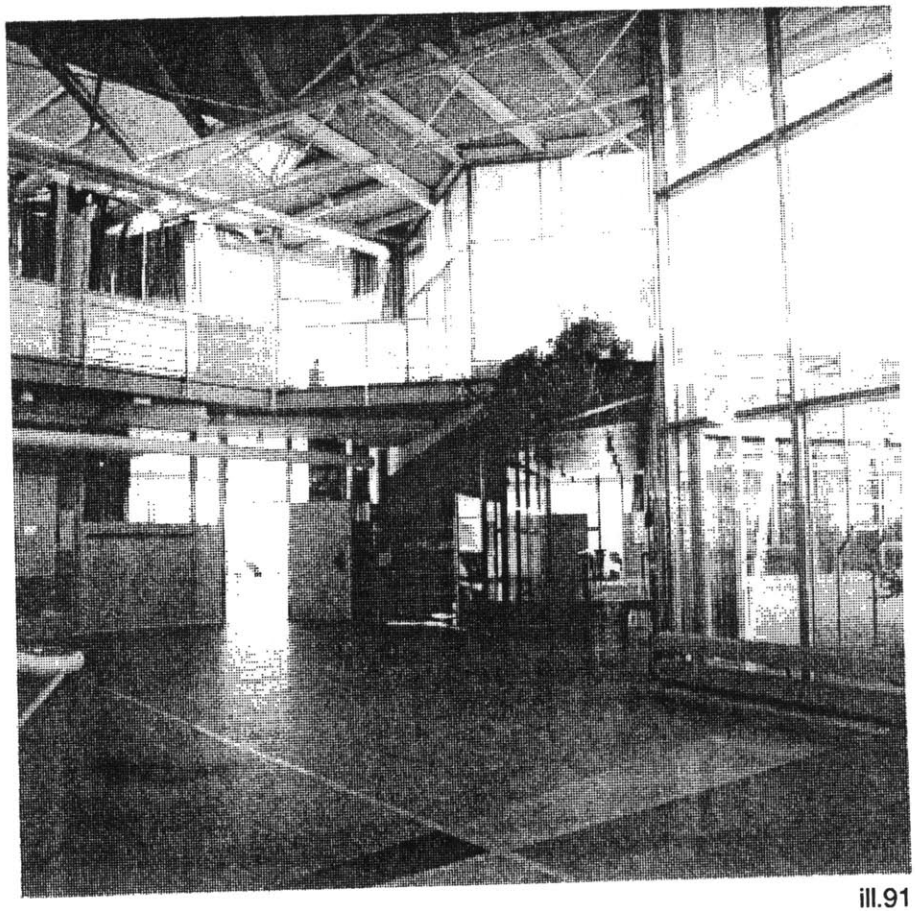


ill.88

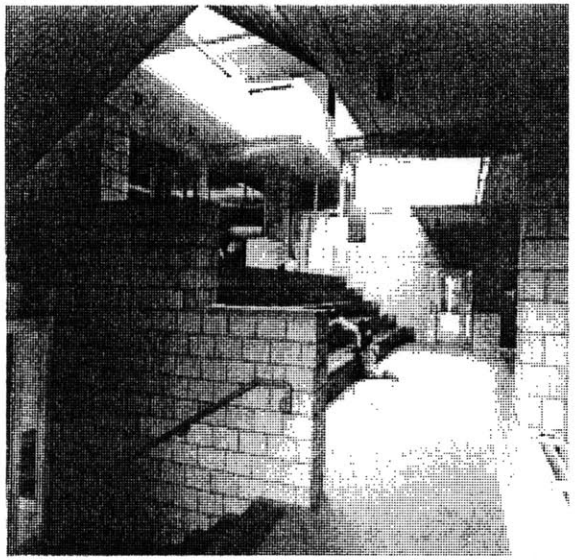


ill.89

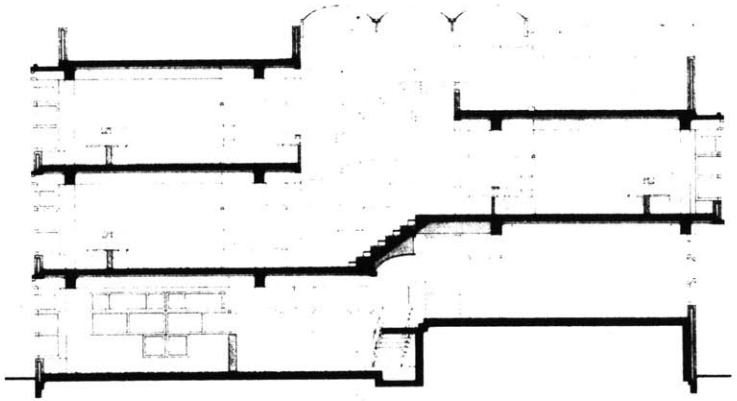
ill.90

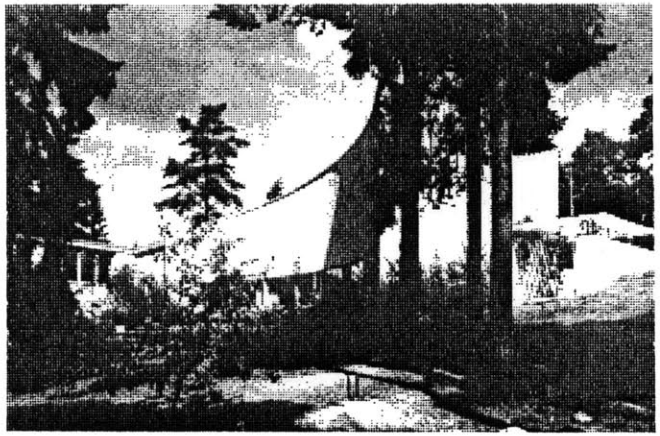


ill.91

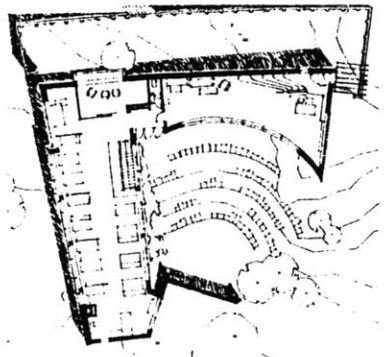


ill.92





ill.93



ARCHITECT'S STUDIO: Helsinki. 1955-56
Alvar Aalto

Appendix

"Bunker Hill" Primary School Program

Daycare: 20 children	= 700 s.f.
Classrooms (12 - 15 children/room)	
Kindergarten	= 475 s.f.
1 - 3 grades (450 s.f. each)	= 1,350 s.f.
Library	= 800 s.f.
Project Area	= 500 s.f.
Offices (1 @ 375 s.f., 2 @ 200 s.f.)	= 775 s.f.
Restrooms (6 @ 150 s.f.)	= 900 s.f.
Storage	= 200 s.f.
Multi-Purpose Room (Auditorium, Cafeteria, Play Area)	= 1,500 s.f.
Total Built Area	= 7,200 s.f.
	+ 20% Circulation
	8,640 s.f.
Play Ground	= 2,000 s.f.
Total Program Area	**10,640 s.f.**

Reference Model Test Data

Model Test Data Sheet

project DON BOSCO

test time 2:30 pm
test date 5-1-89

Lat of model 42°N

sky cond.: sunny
partly cloudy
overcast

* Horizontal sky illum. @ start of test 3000 fc (* same tilt as model)

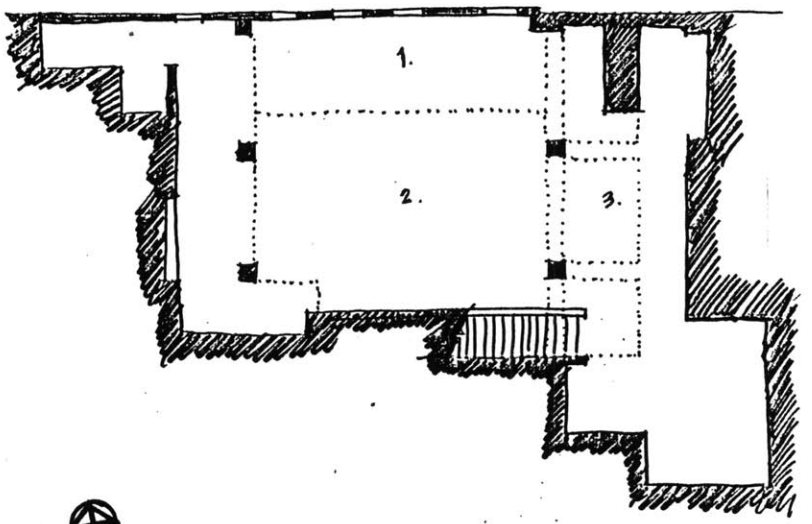
" " @ end of test 3500

(variation of ± .05% ok)

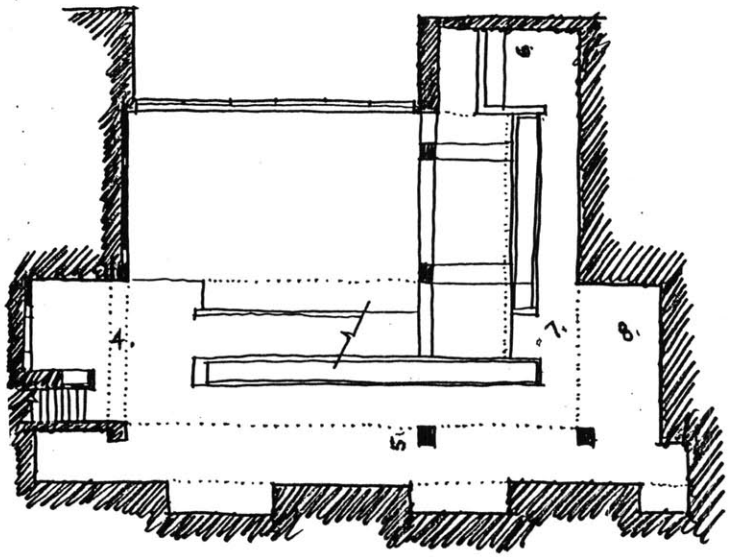
readings*: Test pt. 1 159 fc

(* see plan for pt. locations)

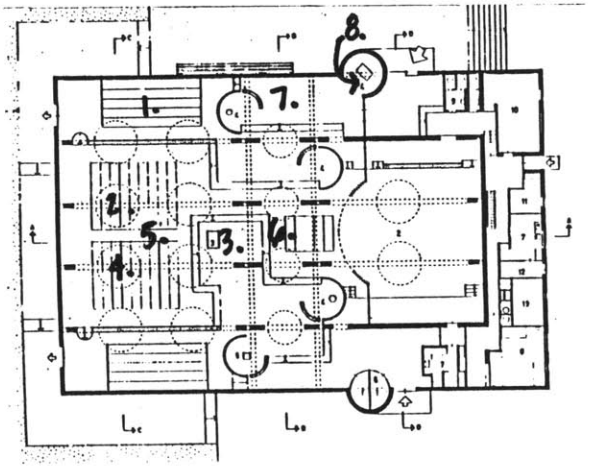
Test pt.		Test pt.	
1	159 fc	5	119
2	137	6	20
3	37	7	158
4	146	8	65



Don Bosco - 4th Flr.



Don Bosco - 5th Flr



Model Test ~~Data~~ Data Sheet

project Van Eyck Church

Lat of Model 52° N

test time 130 pm

test date 5-1-89

sky cond.: sunny / partly cloudy / overcast

(* same tilt as model)

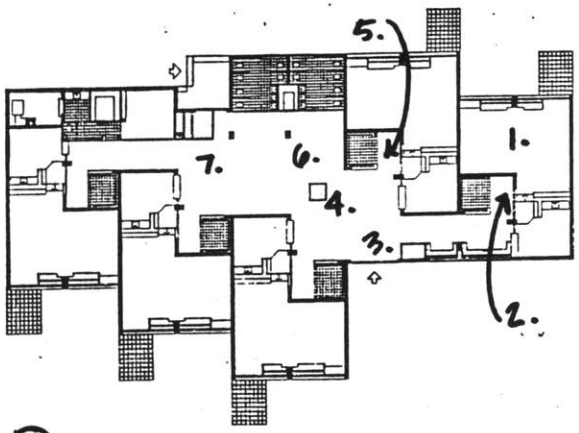
* Horizontal sky illum. ① start of test 3220

" " ② end of test 3500 fc

(variation of ± .05% ok)

~~dmy~~ * Readings: (* see plan for pt. locations)

Test pt.			
1	58 fc	5	145
2	230	6	155
3	170	7	63
4	280	8	30



Model Test ~~Data~~ Data Sheet

project Hoxie School

Lat of Model 52° N

test time 2pm

test date

sky cond.: sunny / partly cloudy / overcast

(* same tilt as model)

* Horizontal sky illum. ① start of test 2930 fc

" " ② end of test 3200 fc

(variation of ± .05% ok)

~~dmy~~ * Readings: (* see plan for pt. locations)

Test pt.			
1	115 fc	5	223
2	235	6	6.5
3	150	7	30
4	10	8	

Model Test ~~Data~~ Data Sheet

project Exeter Library — test time 3pm, test date 5-1-89

Lat of model 42°N — sky cond.: sunny / partly cloudy / overcast

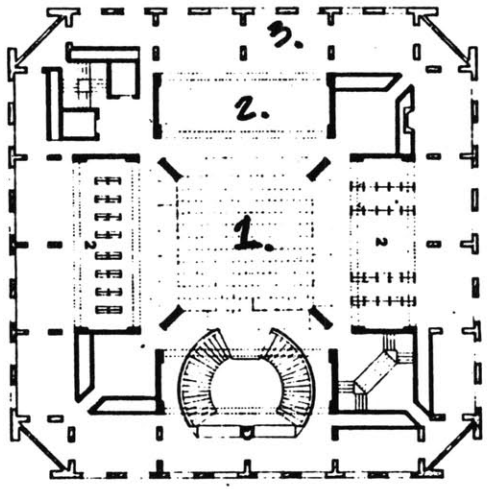
* Horizontal sky illum. @ start of test 5000 fc (* same tilt as model)

" " @ end of test _____

variation of ± .05% ok

~~Data~~ * Readings: (* see plan for pt. locations)

Test pt.			
1	38 fc	5	_____
2	30	6	_____
3	550	7	_____
4	_____	8	_____



Model Test ~~Data~~ Data Sheet

project Aalto Church — test time 1pm, test date 5-1-89

Lat of model 44°N — sky cond.: sunny / partly cloudy / overcast

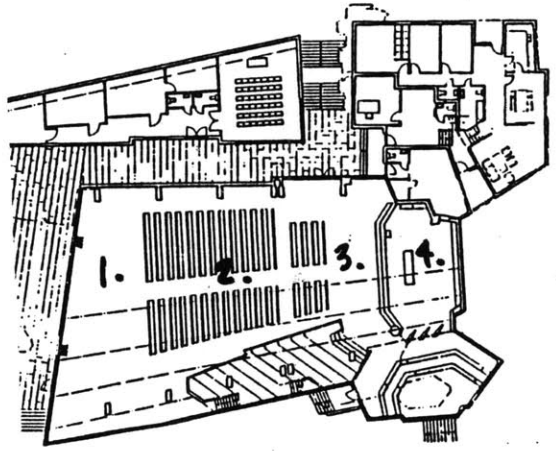
* Horizontal sky illum. @ start of test 3400 fc (* same tilt as model)

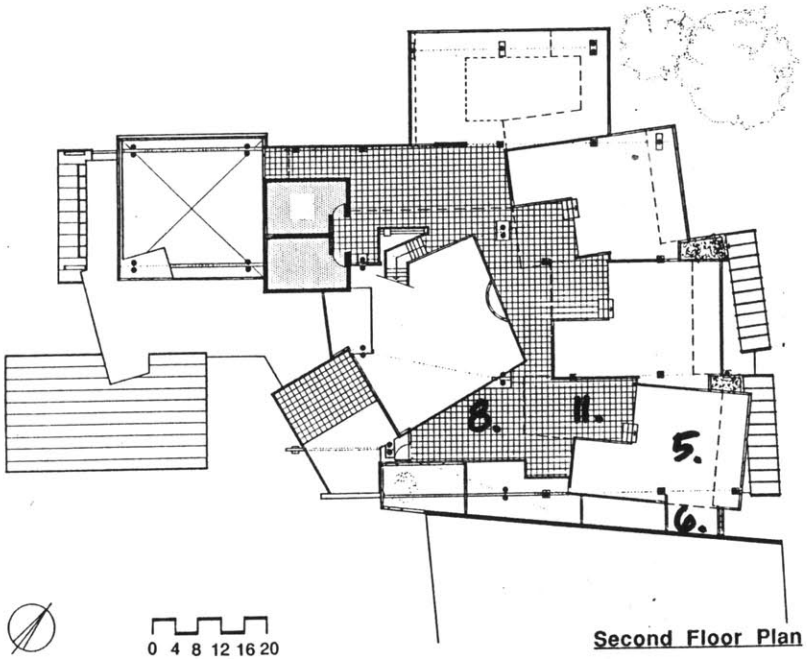
" " @ end of test 3250

variation of ± .05% ok

~~Data~~ * Readings: (* see plan for pt. locations)

Test pt.			
1	375 fc	5	_____
2	340	6	_____
3	280	7	_____
4	290	8	_____





0 4 8 12 16 20

Second Floor Plan

First Floor Plan

0 4 8 12 16 20

Model Test ~~Data~~ Data Sheet

project Design Model

test time 1 pm
test date ~~5-4-89~~

Lat of model 42°N

sky cond.: sunny partly cloudy overcast

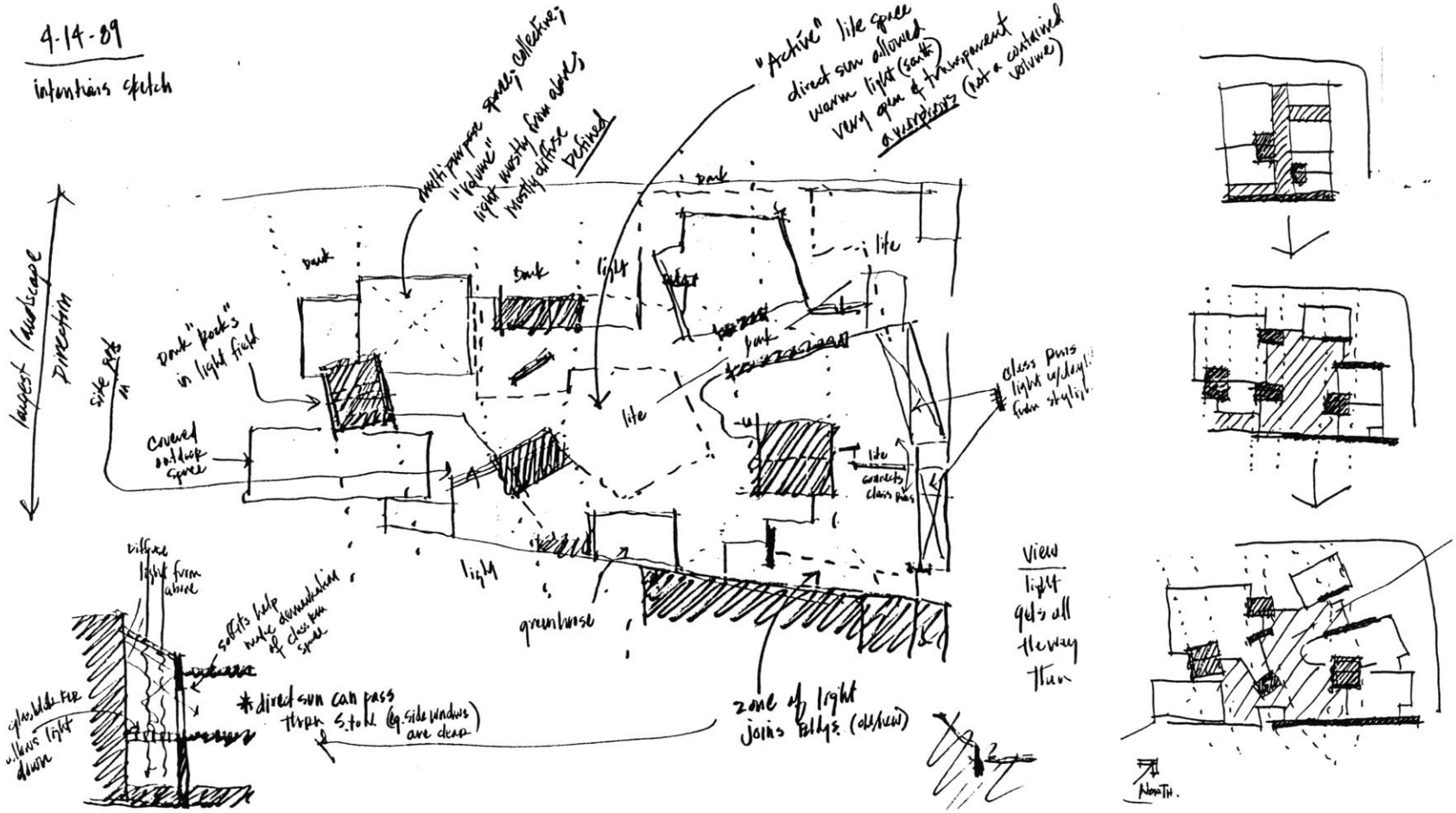
(* same tilt as model)

* Horizontal sky illum. @ start of test 9800 fc

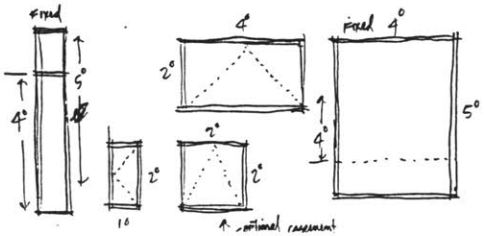
" " @ end of test ——

variation of ± .05% ok.

* readings: Test pt. 1 300 fc
(* see plan for pt. locations) 2 2,970 fc
3 280
4 1180
5 290
6 2,640
7 280
8 4,900
9 2,930
10 1020
11 400
12 160


4-14-89
interiors sketch
multi-purpose space; collective; "volume" light mostly from above; mostly diffuse
"Active" life space direct sun allowed warm light (south) very open & transparent atmosphere (not a contained volume)
dark
light
life
dark "pools" in light field
covered outdoor space
site axis
longest landscape direction
glass passes light w/daylight from skylight
life connects class pods
diffuse light from above
soffits help make determination of classroom space
*direct sun can pass through S. fcade (eg. side windows are clear)
glass block filters light down
greenhouse
zone of light joins bldgs (all/new)
view
light gets all the way thru
North

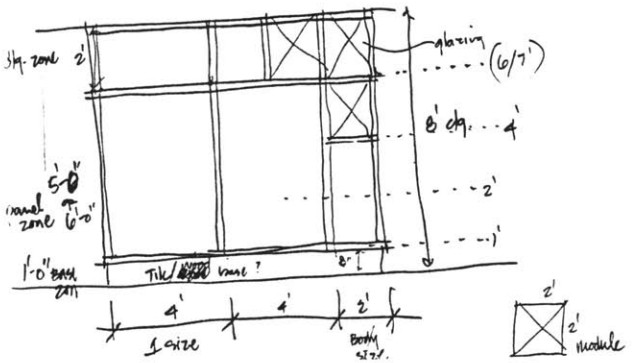
Partition
- nat. wood frame
- G.W.B. panels (4'x8' sht size) painted off-white
- wood panels = Birch pm. metal panels ?
- ~~8" Conc Block~~



WINDOW SIZES:

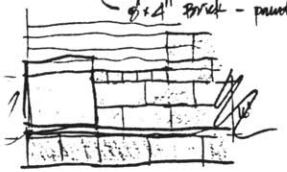
Walls: Systems
- 2 types:
  - Solid; Bearing; Heavy
    - materials: Conc. Block, Granite Tiles, Painted Brick
    - " ← can be continuous
    - glazing in openings at top only
  - Partition; light; non-struct
    - materials are assembled: screen / infill
      - wood; G.W.B. (painted); metal panel; glazing
      - screen has sizes in it

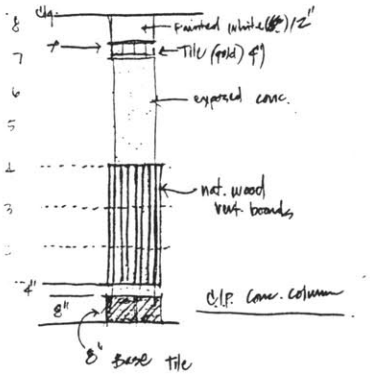
Set up system & push it in terms of LIGHT!



Materials:
- 8" Conc Block — DK. grey 3'x8' = 24'
- Granite tile 2'x2' — pink/grey pepper
- 4"x4" ~~Brass~~ Tiles — gold tape
- 8"x4" Brick - painted White

8" Tile Base (on columns too)





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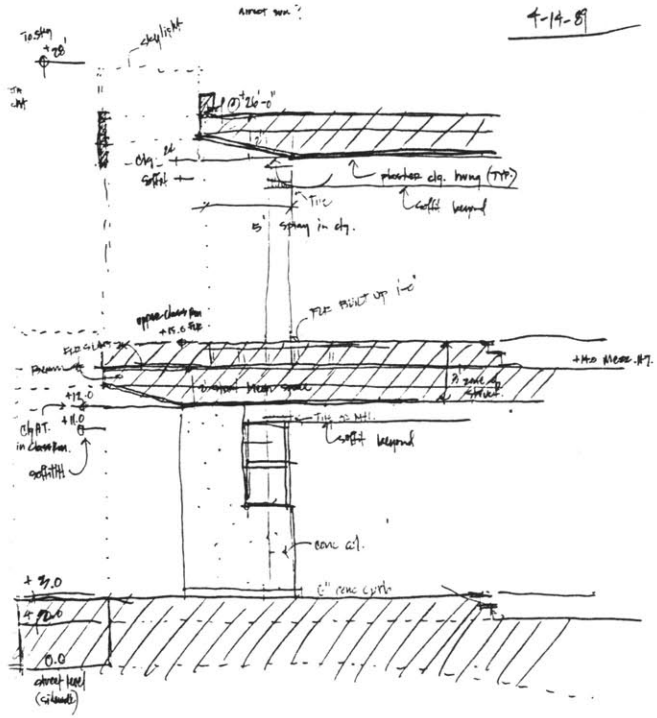

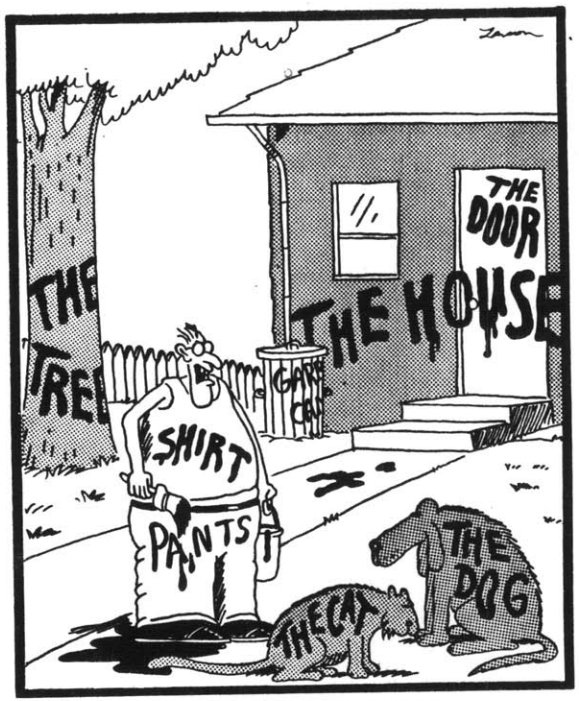

"Now! *That* should clear up a few things around here!"

ill.94

Endnotes

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1 Plummer, Henry; Poetics of Light: A+U Extra Edition; December 1987; page 5.
2 Kepes, Gyorgy, The Language of Vision;
3 Scott, Geoffrey; The Architecture of Humanism; page 168.
4 Zeri, Bruno; The Architecture of Space; page 32.
5 Zeri, Bruno; The Architecture of Space; page 242.
6 Rasmussen, S.E.; Experiencing Architecture;
7 Aalto, Alvar; Synopsis;
8 Plummer, Henry; Poetics of Light: A+U Extra Edition; December, 1987; page 9.
9 Plummer, Henry; Poetics of Light: A+U Extra Edition; December, 1987; page 95.
10 Klee, Paul; The Thinking Eye; page 86.
11 Kepes, Gyorgy; Light as a Creative Medium; page 3.
12 Kepes, Gyorgy; Light as a Creative Medium; page 13
13 Tucker, Jean S.; Light Abstractions.
14 Lobell, John; Between Silence and Light.
15 Turrell, James; Light and Space; Catalog from Whitney Museum of American Art Exhibition, New York, 1980; page 7.

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